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Concerning Sewage Disposal from the Standpoint of Pollution of Oysters and Other Shellfish, and Especially with Reference to their Transmission of Typhoid Fever.

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[This paper contains a concise summary of the most prominent instances of epidemics of typhoid fever and other diseases due to polluted oysters and other shellfish. The literature is reviewed, with numerous references as to the behavior of the germs of typhoid fever in fresh water, salt water and in the shellfish themselves. The extent of the oyster industry and its distribution along the Atlantic seacoast are indicated, together with the mode of growth of shellfish and the relation of their life history to polluted waters, which in some instances surround oyster beds and drinking grounds. Enteric diseases due to polluted shellfish occur with sufficient frequency to call for an improved regulation of this industry, to the mutual benefit of the oyster men and of the public. Suggestions as to means of accomplishment are made, with references to efforts in this direction abroad.—THE EDITOR.

Until quite recently, in considering the disposal of sewage from cities on the sea coast or on tidal estuaries, not much at-

tention has been given except in a general way to the pollution of shellfish.

At present, however, there are some instances where this question is of such importance that it may have much bearing upon the decision as to the best method of sewage disposal to meet the requirements of the near future. To investigate this matter properly there is required a wide range of information in the premises, much of which is not now thoroughly crystallized. Indeed, in a number of ways the evidence is complicated and perplexing, as is indicated by the fact that after several years of investigation the Massachusetts State Board of Health has not formally reported upon the subject; and also that the Royal Commission on Sewage Disposal in Great Britain in its elaborate reports of last year left many important details still undecided.

Academically this question is not new. It is ninety years since the available records first show reasonably authentic cases of typhoid fever having been caused by the eating of infected oysters. It is more than ten years since the epidemic of typhoid fever at the Wesleyan University, at Middletown, Conn., was shown so clearly by the classical investigations of Prof. Conn to have been due to infected oysters. From various places evidence is forthcoming as to disease having resulted in sporadic cases from the eating of oysters which were polluted with sewage.

The "oyster scare" is founded upon fact to a sufficient degree to deserve serious attention, and that it has not been more completely and satisfactorily investigated indicates, in the opinion of the writer, the absence of a keen appreciation of the sanitary welfare of the public and also of the interests of the oyster industry.

The purpose of this paper is not to bring forth any new data, but rather to summarize briefly the more authentic information in the premises now available from various sources, and to point out some lines along which further data are needed before this subject may reach a sound and logical conclusion, having due regards to the interests of all concerned.

Epidemiology, bacteriology, sanitary chemistry and hydraulic engineering are called to assist in the solution of this problem, in conjunction with those physical data usually called a

"sanitary survey." The breadth of this subject is indicated by the following list of topics here considered. To consider one aspect of the case will not do, as such evidence might be misleading to such a degree as to do far more harm than good. In the future the engineer will especially be obliged to consider this question in further detail, and to co-operate in seeing to it that various sanitary surveys and samples for analysis have due regard for the physical side of the case, as, for example, the currents, tides, winds, relative volumes of sewage and of fresh and salt water (tidal prisms), velocity, dilution, effect of sedimentation and scouring, temperature, relative densities of water, stratification, and especially the period of time elapsing during the passage of sewage from the outfalls to the shellfish beds and "drinking grounds."

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EARLY INSTANCES OF AND REFERENCES TO DISEASE TRANSMISSION THROUGH INFECTED OYSTERS.

Even prior to the germ theory of disease numerous cases were cited of the well established relationship between typhoid fever, cholera and similar intestinal diseases and the eating of oysters and other shellfish taken from polluted sources.

The first instance on record was cited by Dr. Pasquier[1]* in 1816. This French physician wrote a book entitled "The Oyster from the Medical Point of View," and in it described an instance where a workman laid down 60,000 oysters in a fattening bed excavated in the moat of an old citadel into which the sewage of the garrison had been discharged for centuries. These oysters were consumed for the first time on September 10, 1816, and on the 20th and 21st of the same month, after the lapse of the necessary period of incubation for typhoid fever germs, cases of that disease made their appearance among the consumers.

In 1820 the British medical journals[2] record an outbreak of gastro-enteritis at Dunkirk which was reported to have been due to oysters procured on the coast of Normandy.

During the cholera epidemic in Great Britain in 1849 an outbreak of this disease occurred at Bridgewater and Taunton, which was considered to have been due to the consumption of some apparently decomposing oysters which had been condemned as unfit for food, but which were, nevertheless, given to school children in the district. This outbreak was officially examined by Dr. Britton, of the General Board of Health, and was referred to a little later in medical literature by Sir D. W. Richardson[3].

In 1876, on the Isle of Man there occurred an epidemic of typhoid fever[4] which was alleged to have been due to the consumption of oysters.

The earliest reference in recent medical literature to this subject occurs in a paper read before the British Medical Association, in 1880, by Sir Charles Cameron[5], Health Officer of Dublin, Ireland. His proposition that oysters obtained from polluted sources might cause typhoid fever was so novel that the chairman of the meeting inquired if his paper were intended as a joke. In 1889, it appears from the investigations of this gentleman that cases of typhoid fever in Dublin[6] were recorded as possibly having had their origin from oysters which had been laid down in the sewage-polluted Dublin Bay.

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*The numbers appearing throughout this paper refer to the list of references which has been consulted, and which appears at the close of the paper. Acknowledgment is here made for the use of information quoted from the several authors and reports as indicated.

Prof. de Giaxa, of Pisa, made a study of the bacterial flora of the Bay of Naples and in his paper[7] in 1889 recorded some observations on the longevity of disease germs in salt water, and referred then and later[7a] to the question of infection by shellfish.

Following the epidemic of cholera in Hamburg late in 1892 there appeared some scattering cases of cholera in England which were considered to have been directly caused in part by the consumption of oysters from Cleethorpes and Grimsby, according to Sir R. Thorne Thorne[8], Medical Health Officer of the Local Government Board, and Dr. Reece, Inspector.

RECENT OUTBREAKS OF TYPHOID FEVER DUE TO INFECTED OYSTERS AND OTHER SHELLFISH.

The epidemic of typhoid fever which has attracted most widespread attention was that at Wesleyan University, at Middletown, Conn. As stated in the admirable report of Prof. Conn[9], there were seven fraternity banquets on October 12th, 1894, at Middletown, which were attended by about 100 students, some of whom were guests from other universities. Following the ordinary period of incubation of typhoid fever, 23 cases of this disease appeared among the local students and six cases among the guests who had attended three of these banquets. By a most exhaustive inquiry there were eliminated other foods which might possibly have conveyed the typhoid fever germs, including water, ice, milk, ice cream, uncooked vegetables, etc. By eliminating these articles of food and drink and by comparing the portions of the menu eaten by those who did and by those who did not sicken of typhoid fever, and further by comparing the diet before and after the banquet of the various students and guests, there was left no room for doubt about the uncooked oysters being the source of infection. Additional weight was given to this conclusion by the appearance of typhoid fever among six of the guests who had eaten oysters at these banquets but who had not otherwise been exposed to any local factors; and by the further fact that no typhoid fever appeared among students attending on the same evening the other banquets at which oysters were served either from other sources or were cooked.

Investigation showed that the oysters in question had been obtained from Fairhaven, Conn. They had been taken from deeper water in Long Island Sound and brought into the mouth of a creek known as Quinnipiac River and allowed to lie in brackish water for a day or two for fattening. Close to the fattening beds were the outlets of a number of private sewers, one of which, 300 feet distant from the bed, drained a house in which were two cases of typhoid fever. Each link in the chain of evidence was established beyond all reasonable doubt.

It was the Middletown epidemic which first drew the attention of the public in a prominent way to the relation between shellfish and disease. Since that time many instances have occurred of somewhat similar character.

Among those which were investigated most carefully by competent official sanitarians may be mentioned the mayoralty banquets[10] in 1902 at Winchester and Southampton, England. In this instance there were two banquets, held on the same evening in distant towns, at which oysters from the same polluted source were served uncooked. At each banquet a considerable portion of the guests were shortly siezed with gastro-enteritis, and others were later attacked with typhoid fever. Of 267 guests, 118 suffered from the former and 21 from the latter disease.

Instances of such outbreaks are a matter of record in nearly all countries where oysters or other shellfish are eaten in an uncooked condition. It is needless here to recite them all in detail, the particulars of which can be largely ascertained in Dr. Bulstrode's testimony[4] and his classical paper[11] on "Oysters Culture in Relation to Disease," and in the excellent summary prepared in 1901 by Dr. Harrington[12]. As a matter of convenient record, however, reference may be made here to a few of the more prominent ones, as follows:—

Truro, England.—A supper party of seven in this city was reported to have eaten oysters from a source known to be polluted. All of them were taken ill, some with typhoid fever and some with gastro-enteritis. The Medical Officer of Health of the city, Dr. Sharp[13], reported in 1897 that the infected oysters were the cause.

St. Andre de Sangonis, France.—Dr. Chantemesse[14] read a

paper on this subject before the Paris Academy of Medicine. He drew attention to 14 persons in 6 families having eaten raw oysters taken from the sewage polluted canal at Cette. All of these persons were made ill, some with typhoid fever and some with gastro-enteritis, while no illness whatever appeared among the members of these families who ate no oysters.

Dr. Mosny[15], who wrote an excellent series of articles five years ago on "Mollusk Poisoning" in France, refers to a more recent instance in a village near Paris, where gastro-enteritis followed the eating of oysters from Cette.

Other instances of oyster pollution are reported from Monte Carlo[16], Naples[16], Florence[17], Milan[18], Constantinople[19] and New Zealand[20]. Numerous physicians could doubtless recite cases of shellfish infection within their observation, typical instances of which were recorded by Sir William Broadbent in 1895[21].

Clams[22], mussels[23] and other shellfish have been found to transmit disease, but as they are not so generally in use as oysters (at least in America), the well-known cases are not so numerous as with the oysters.

Patrons of summer resorts, especially at the seashore, doubtless suffer more from infected shellfish as a general proposition than is believed by many. To trace clearly the significance of such factors in a floating population is obviously difficult. It is of interest, however, to mention the recent instances at Atlantic City and at Lawrence, L. I.

Atlantic City, N. J.—This well-known seashore[24] resort, although provided with a public water supply of satisfactory quality, and with a milk supply found upon careful examination to have been safe, has at times suffered from an undue prevalence of typhoid fever, especially during the summer of 1902. The cause of this typhoid fever was found to be largely due to oysters freshened in sewage-polluted waters, and clams taken from similar waters, according to an investigation[24] made by the Atlantic City Academy of Medicine. This conclusion[25] was concurred in by Prof. A. C. Abbott and Prof. Henry Leffman, of Philadelphia. Since the taking of shellfish from polluted sources has been prohibited by the local Board of Health

there has been no abnormal prevalence of typhoid fever[26] at this resort.

Lawrence, L. I.—This small summer resort on the Rockaway peninsula, on the south shore of Long Island, suffered during the summer and autumn of 1904 from a sporadic outbreak of typhoid fever, the total number of cases being thirty-one. According to the careful investigation of Dr. Soper[27] more than two thirds of these cases were traced directly or indirectly to shellfish taken from the adjoining coves of Jamaica Bay, the water of which is polluted with local sewage.

RELATION OF SHELLFISH TO THE GENERAL PREVALENCE OF TYPHOID FEVER.

A moment's reflection will show that the most serious aspect of oyster pollution does not relate by any means to outbreaks at large banquets or summer hotels, but rather to the significance which this proposition bears to the various cases of this disease scattered throughout the entire world of oyster-eating people. It is well known that typhoid fever frequently appears among people who, so far as can be ascertained, have not been exposed to infected water, milk or other foods, and which constitute what are generally called sporadic or isolated cases of typhoid fever.

To ascertain even in a general way the relation of various shellfish to these isolated cases is a very difficult and complicated matter. In the recent inquiry conducted in a most careful manner into this general proposition by the Royal Commission[28] of Great Britain on the Disposal of Sewage, a circular letter requesting information upon this subject to thirty-one county councils, drew forth the fact that twenty-one of them had no evidence bearing upon the question. The principal information elicited by these letters from the remainder may be briefly summarized as follows:

Southend-on-Sea, England.—The Health Officer, Dr. Nash[29], expressed his opinion, as the result of careful investigation, that at least 50% of the typhoid fever was due to the consumption of shellfish from sources contaminated by sewage.

Yarmouth, England.—Dr. Nash also quoted typhoid fever statistics from Yarmouth[29], where this disease had prevailed to a high degree for several years prior to 1900, when the sale

of mussels from the River Yare was stopped. In 1901 the typhoid fever records showed only about 30% of the previous average, and in 1902 there was a still further reduction.

Brighton, England.—During the years 1894 to 1902, the Health Officer, Dr. Newsholme[30], investigated each case of typhoid fever in Brighton and found that out of a total of 643 cases 158 were directly ascribable to the consumption of oysters and eighty other cases to the consumption of other shellfish within the period of incubation. These shellfish in each instance were taken from layings proven to be exposed to sewage pollution. In the opinion of Dr. Newsholme 37% of all cases as indicated above is an under estimate of the effect upon that community of polluted shellfish.

Manchester, England.—During the years 1897 to 1902, inclusive, 2664 cases of typhoid fever occurred, and according to the Health Officer, Dr. Nevin[31], 118 of these were strictly ascribable to oysters and mussels, and 156 more were associated with the consumption of other shellfish. In round numbers, therefore, in the city of Manchester about 10% of the typhoid fever during this period seems to have been due to polluted shellfish.

London, England.—According to Health Officer Murphy[32], of the Metropolitan District of London, more than 8% of all the typhoid fever in that district during 1902 was indicated by consistent evidence to have been caused by polluted shellfish.

In America the evidence obtained as to the relation between typhoid fever and shellfish has not been exhaustively studied, although it has received considerable attention in New York City[33] and in some other places. There are no adequate data on which to base any comparisons with the experiences in the English cities above cited. When the much-needed data upon this question are available it will probably be found that the wider use of shellfish in America than in Europe will be a factor; although, of course, the net result depends upon the number of infected oysters reaching a given population.

EXTENT OF THE OYSTER AND CLAM INDUSTRY.

The principal oyster in America, *Ostrea Virginiana*, is found along the Atlantic coast, from Cape Cod to Texas. The extent of this industry and an approximate idea as to its relative

distribution along the coast is shown in Table No. 1. These annual statistics are compiled from the bulletins[84] of the U. S. Bureau of Fisheries, Department of Labor and Commerce. They cover the year 1902, except in the case of the Middle Atlantic States, where the records are for the year 1901.

TABLE No. 1.

	Market Oysters		Seed Oysters		
	Bushels	Value	Bushels	Value	Total Value
Massachusetts	75,586	$ 120,252	27,800	$ 13,430	$ 133,682
Rhode Island.....	516,479	561,291	91,550	26,761	588,052
Connecticut	848,065	872,634	1,233,469	598,948	1,471,582
New York.....	1,768,703	1,703,985	544,075	267,555	1,971,540
New Jersey.....	2,092,335	1,696,767	1,516,796	550,918	2,247,685
Pennsylvania	40,336	35,517	43,234	14,232	49,749
Delaware	96,900	40,290	76,290	22,318	62,608
Maryland	5,685,561	3,031,518	.....	.....	3,031,518
Virginia	6,067,669	2,621,915	1,817,778	301,541	2,923,456
North Carolina....	1,022,813	268,363	.....	.....	268,363
South Carolina....	689,700	118,460	.....	.....	118,460
Georgia	1,224,000	220,467	.....	.....	220,467
Florida	888,556	161,296	.....	.....	161,296
Alabama	347,460	119,773	.....	.....	119,773
Mississippi	2,405,132	426,222	.....	.....	426,222
Louisiana	1,198,413	493,227	.....	.....	493,227
Texas	343,113	100,359	.....	.....	100,359
Totals	25,410,821	$12,592,336	5,350,992	$1,795,703	$14,388,039

In Table No. 2 are given corresponding annual statistics showing the extent and location of the clam industry. The so-called "Little Neck" clam, or small round clam, in most general use is here classified as the hard clam, or what is commonly known in New England as the "quahog."

TABLE No. 2.

	Hard Clams		Soft Clams		
	Bushels	Value	Bushels	Value	Total Value
Maine	.....	.....	417,496	$148,742	$ 148,742
New Hampshire..	.....	.....	3,000	3,000	3,000
Massachusetts	106,818	131,139	227,941	157,247	288,386
Rhode Island.....	27,155	35,456	26,490	32,514	67,970
Connecticut	18,927	24,762	22,460	26,743	51,505
New York.....	184,736	257,756	77,945	58,843	316,599
New Jersey.....	530,759	552,953	90,277	54,918	607,871
Delaware	1,025	1,203	.....	.....	1,203
Maryland	13,450	14,384	.....	.....	14,384
Virginia	220,585	134,777	.....	.....	134,777
North Carolina...	146,897	86,662	.....	.....	86,662
South Carolina....	28,133	12,940	.....	.....	12,940
Georgia	1,250	825	.....	.....	825
Florida	750	425	.....	.....	425
Totals	1,280,485	$1,253,282	865,609	482,007	$1,735,289

On the Pacific coast there are two local varieties of oysters

found, available records indicating that the annual output amounted to 519,340 bushels, having a first value of $971,829.

A general idea of the extent of the oyster industry throughout the world is shown in Table No. 3, the annual statistics[35] of which it is to be stated are not strictly comparable, as they refer in various instances to different years, beginning about 1890 and extending down to the present time. They are sufficient, however, for present purposes in conveying a general impression as to the relative extent of this important industry.

TABLE No. 3.

	Oysters.	
	Bushels.	Value.
United States	28,138,434	$14,313,753
Great Britain	2,760,000	6,200,000
France	2,000,000	5,000,000
Canada	152,580	183,846
Holland	70,000	444,000
Italy	65,000	200,000
Germany	13,000	75,000
Other countries	400,000	600,000
Totals	33,599,014	$27,016,599

The value of the annual output[36] of oysters, clams and other mollusks amounts in the United States to about one-third of the total volue of all fisheries, as shown in Table No. 4.

TABLE No. 4.

Oysters and other molusks	$16,700,524
Lobsters and other crustaceans	2,251,869
Whales, seals and other animals	1,321,247
Menhaden (for oil and guana)	973,200
Sponges	305,589
Turtles, terrapin, alligators, frogs	254,922
Food fishes in general	27,889,588
Total	$49,696,939

CONCERNING THE LIFE HISTORY OF THE OYSTER.

It is not the intention of this paper to enter into a detailed technical description of the anatomy or physiology of the oyster. It is desired, however, to refer somewhat briefly to those well-known features of its mode of living which bear a relation to possible opportunities for the oyster to become polluted when placed in water containing sewage or other undesirable drainage.

Larval Oysters.—Like all other mollusks, the oyster reproduces exclusively by eggs. Each spatting oyster is estimated

to give rise to more than 1,000,000 ova in a single season. From the eggs there are hatched small free-swimming larvae, which swim about for a short time until the shell appears. They drift about with the tide, current or wind and are carried frequently far away from their native bed. A large proportion of them, however, never reach maturity. Not only are the larvæ destroyed by cold and by living enemies in the water, but many of them perish by becoming deposited in muddy places, where survival is impossible. After the larvae pass through the free-swimming stage for a few days, those which develop further become fixed upon some hard, clean substance.

Oyster Spats.—When the shell of the infant oyster becomes large enough to cause deposition it is commonly called at this stage of development the "oyster spat." It has the appearance of a white glistening speck, not unlike a spot of candle grease. The spatting season varies in different localities, but ordinarily occurs within the period from May to September, inclusive. The oyster farmer gives careful attention to the "fall of spat," and in many instances artificial collectors are provided upon which they may become deposited. These frequently consist of clean empty oyster shells, branches of trees, tiles, etc. In the natural beds the spats become attached to rocks or reefs; if they do not reach some solid support they obviously sink in the mud and become smothered. Care is required to keep the beds in good condition as to freedom from weeds, deposits and antagonistic kinds of life.

Seed Oysters.—The seed oyster is one which has grown sufficiently upon artificial collectors until it has reached perhaps one year of age or so, when it is frequently removed to other beds. It is said that about 40% of the oysters in the United States are obtained from natural beds, and the remainder are transplanted to places where the oyster does not breed or grow to advantage. Probably the most important factor of all is the fact that the natural beds cannot supply the demand. For some time oyster transplanting has become an industry carried out on a large scale in this country, and is now receiving much attention. The future will doubtless see still further attention to oyster culture.

Food Supply.—The oyster lives on the various suspended matters contained in sea water, about 90% of the food being

diatoms, or low forms of plant life which are capable of growing on the mineral contents of sea water. This suspended matter reaches the stomach of the oyster after having been filtered out from the water which passes through the gills. This process[37] is well described by Prof. Brooks, of Johns Hopkins University, as follows:

"Every oyster in the bay is engaged day after day throughout the year, all day and nearly all night, in drawing into its shell a stream of water, filtering this through its gills, and then discharging this stream of water again. This stream can be traced for five or six feet away from the oyster by the disturbance it produces in the water. In fact, I think it is hardly an exaggeration to say that every drop of water that enters the Chesapeake Bay from the Susquehanna River has a good chance to be filtered through the gills of an oyster before it reaches the ocean. After the oyster draws this stream of water into its shell, the water passes through microscopic pores over the surface of the gills, and out again through the vent pipe. During this process all microscopic organic life, or most of it, is filtered out. This is so true that those who manage aquaria have long been aware that water that has been filtered by the fresh water mussel is peculiarly adapted to their use, because it does not contain the germ of the green algae, which grow so profusely upon the sides of glass vessels, this material being so perfectly taken out by the mussel that the glass remains clean for a long time. The oyster does the same thing. These organisms, instead of going through the pores of the gills with the water, are entangled in the cement which the gland cells of the gills are continuously pouring out, and they are pushed along until they reach the mouth of the oyster, and are passed along into the stomach, where they are ultimately digested and converted into the wholesome substance of the oyster."

Fattening of Oysters.—In all countries one of the characteristic features of the oyster industry is the frequent, though not universal, custom of removing the oysters with rakes or dredges, after they have grown to be a sufficient size, from the oyster beds proper and their placement for a day or two in drinking houses, or floats. The latter are located ordinarily in coves or bays, or in the mouths of fresh water streams where the water

is brackish. The object of this is to "fatten" the oyster, which really means to bloat, bleach and freshen it. This is accomplished by the oyster drinking a comparatively large quantity of the brackish or fresh water, thereby, on account of difference in the specific gravity, causing it to become bloated, with the salty flavor due to sea water largely removed, and also giving it a much lighter color, due to its being filled with fresh water.

This bloating process—which the oystermen say increases the market value of the product, but which is seriously objected to by devotees of fine oysters—is not to be confused with fattening, which in a limited way is done by transplanting to shallow bodies of salt water where the diatomaceous food is more abundant[38] than around the natural beds. The latter process is an important branch of artificial oyster culture which has long received attention in France and elsewhere.

Enough has been said above to make it plain that the oyster, even in natural beds, may at times be found in a water which is dangerously polluted with sewage, and that particularly dangerous pollution may be afforded by the custom of bloating the oysters by removing them just prior to their being marketed to special layings along shore. It is also apparent from what is said above that if disease germs are contained in the water in which the oysters are placed, there is a strong likelihood of these germs being filtered out by the oyster as the water passes through its gills, and entering the body of the oyster.

We will now trace the available evidence as to the significance of disease germs entering the oyster body.

CONCERNING THE DETECTION OF TYPHOID FEVER GERMS IN OYSTERS AND WATER.

In the present state of the art, bacteriology does not afford ready and reliable means[39] for the detection and isolation of the bacillus of typhoid fever when present in such numbers as ordinarily exist in nature. With difficulty the numbers present may be roughly approximated only in the laboratory when those present are excessively numerous due to artificial infection of the oyster or the water.

Accordingly, in the absence of direct means of studying the distribution of this germ in oysters and associated waters, it becomes necessary to study the problem indirectly. Along the

latter line there are five principal ways of approaching the subject, viz.:

(a) Evidence as to the longevity of the typhoid germ in sea water. This evidence is, of course, considered in connection with the time interval required for the passage of sewage from the local outfalls to oyster beds in the vicinity.

(b) Topographical and physical evidence, such as distances, depths, volumes, tides, currents, etc., for studying each local problem as indicated in the foregoing paragraph.

(c) Comparison of the numbers of bacteria and organic contents of the water from above the oyster beds with that of sea water from unpolluted sources, paying special attention to the relative numbers of B. coli, which is the most prevalent species of bacteria in the intestines of man and other warm-blooded animals.

(d) Comparison of the B. coli contents of oysters (including the body, liquid and shells) from unpolluted sources with those from the locality in question.

(e) Evidence, so far as present methods of bacteriology permit, as to the behavior and duration of life of typhoid fever germs within and upon oysters which have been infected with this germ.

LIFE OF TYPHOID FEVER GERMS IN SEA WATER.

Available evidence, summarized in Table No. 5, indicates that this germ will live in unsterilized sea water in gradually decreasing numbers for periods ranging at least from about one week to one month, depending upon local conditions.

TABLE No. 5.

Observer	Date.	Days after Infection when Germ was last Observed.
De Gaixa[7]	1889	9
Foote[40]	1895	17
Klein[41]	1896	21
Burdoni-Uffredizzi[19] and Zenobi	1889(?)	14
Herdman & Boyce[42]	1899	20
Field[43]	1904	10

No observer has noted any signs of the typhoid germ multiplying in sea water.

According to Klein[41], germs of Asiatic cholera behave in a

similar manner in sea water to typhoid germs, except that their continuance of life is apparently somewhat shorter.

Experiments have been made both by Klein[41] and Field[43] in which there was a gradual displacement of the infected sea water by uninfected sea water. The apparent result was a shortening of the life of the typhoid germ, but it is not clear how far this was a matter of elimination from the vessel by displacement of the water containing them.

In all other tests included in the above tabulation the infected sea water remained undiluted.

Generally speaking, it is seen that the life of the typhoid fever germ in salt water is very similar to that in fresh water, according to a diagram prepared by Whipple[44] and embodying all of the best available data. Careful experiments recently made jointly by Jordan, Russell and Zeit[45] indicate, however, that hostile influences within the local Chicago drainage canal water (fresh and sewage polluted) may cause the vast majority of typhoid germs to perish within three or four days. They specifically mention that these data are not intended to be representative of all conditions in all bodies of water. In this regard attention is directed to the fact that, due to the limits in accuracy of present laboratory methods, some disease germs without any question remain in the water for a longer period than indicated by the data here given. This obviously follows when consideration is given both to the difficulty in detecting typhoid fever germs when sparsely distributed in water and to the fact that the examination in question involved the testing of a far smaller volume of water than is daily drunk by an oyster. In short, 90% of the typhoid germs disappear from infected water according to different local conditions in from 3 to 13 days, according to Whipple's[44] diagram; and while the remainder, without doubt, gradually perish, there is no way at present of stating the period of survival of the last 1% or 0.1%.

The use of parchment sacs is supposed to have improved the technique of determining the longevity of typhoid germs in water; but very recently doubt upon this point has been thrown by the observations of Messrs. Johnson and Copeland, indicating that motile bacteria may pass through unpunctured sacs. It is hoped that further data on this subject will be forthcoming in the reports from the Columbus Sewage Testing Station.

BACTERIAL CONTENTS OF UNPOLLUTED SEA WATER.

Numbers of Bacteria.—Far distant from the land the water of the ocean, while by no means sterile, contains comparatively few bacteria, and all of these appear to be of a harmless kind. Thus, Levin[46] found during an expedition to the Arctic regions that the water in that locality according to the average of numerous analyses contained 11 bacteria per c.c. This number he compares with 700 per c.c. as the contents of sea water off the shores of Sweden.

In midocean, on a voyage across the Atlantic, Minervini[47] found that the number of bacteria ranged from 8 to 140 per c.c, and averaged about 60 per c.c. That these samples were not sterile is not so surprising as might appear at first sight, as the flora and fauna of ocean waters naturally furnish food for bacterial life. Thus Minervini[47] records that in midocean several tests of the organic matter in sea water showed about 25 parts per million of oxygen consumed, according to the Kubel method.

These numbers found in the middle of the Atlantic Ocean correspond quite closely with those found about two and one-half miles or more distant from the coast by Russell[48] in the Gulf of Naples and by Carta[49] in the Gulf of Genoa.

The sediment on the bottom of the ocean was studied by Russell[48] and found to bear quite a close relation to the relative numbers in the water above when the distance from shore exceeded that covered by the zone showing immediate effect of shore pollution. Within this zone, showing gradually decreasing effect of pollution, numerous bacteria were naturally found in the sediment.

Fisher[50] also made numerous examinations of sea water on a prolonged ocean voyage to the Antilles, and found the bacterial contents to be generally similar to the above.

Tests for B. coli.—B. Coli is the principal species and by far the most abundant one in the intestines of man[51] and other warm-blooded animals[52]. Waters in which this germ is regularly absent in from 1 to 10 c.c., are found to be quite unpolluted, while the pollution ofwaters is now quite generally measured by the comparative numbers of B. coli present, according

to methods recently formulated both in America[89] and Great Britain[53].

The evidence is decisive that unpolluted sea water, remote from sources of pollution, contains no B. coli. The most complete tests available were made for the Royal Commission on Sewage Disposal by Dr. Houston[54]. Of thirty-five samples of sea water collected off the coast of Scotland within sight of land but distant from any appreciable local pollution, thirty-four were found to contain no B. coli even when 100 c.c. portions were examined. The remaining sample gave a positive test with 10 c.c.

This evidence is in accordance with the result of studies as to the distribution of numbers of bacteria and of B. coli which have been made in this country of the waters of the Great Lakes some distance from land, especially in the vicinity of Toronto[55], Chicago[56], Milwaukee[57], Oswego[58], Buffalo[59], and Cleveland[60].

Influence of Fish.—The question of fish comes up for consideration with reference to B. coli being found in sea water at points considerably removed from sewage pollution. The evidence upon this point is not as complete as desired, but the observations of Amyot[61] and Whipple[62] indicate that B. coli is not a normal inhabitant of the intestines of fish. The studies of Russell and Bassett[63] leave the matter in doubt, but Johnson[64] found that where fish live for some time in polluted waters the intestines of the fish contain this germ. On the whole it is quite apparent that in unpolluted sea water B. coli coming from fish does not interfere seriously with the proposition that B. Coli is absent from such water.

Influence of Birds.—While the fecal discharges of birds[52] contain B. coli, the influence of this factor is apparently negligible as a general proposition upon the normal contents of deep sea water. Exceptions could appear only in chance samples, which are always to be avoided as they are apt to lead to errors.

Influence of Boats.—Refuse matter discharged from boats in the opinion of some is entitled to some weight as a factor influincing the quality of deep sea water. At intervals this is probably true for small volumes, but the effect of such would be hardly appreciable in a comprehensive set of examinations.

Generally speaking, we may say that deep sea water distant from local sewers is unpolluted according to B. coli tests.

BACTERIAL CONTENTS OF OYSTERS AND OTHER SHELLFISH TAKEN FROM UNPOLLUTED WATERS.

The most exhaustive investigations upon this subject show that normally the oyster and other shellfish contain not only no specific disease germs, such as that of typhoid fever, cholera, etc., but, further, that the oyster contains no Bacillus coli, which, as already stated, is the prevailing organism in the intestines of man and other warm-blooded animals.

Dr. C. A. Fuller[65], formerly of Brown University, Providence, R. I., examined most carefully various portions of each of 200 oysters taken from unpolluted sources, as well as the liquid contained in the shell. In no instance did he find any bacteria which could be classed with the B. coli group.

Clark and Gage[66], who have investigated this matter extensively for the Massachusetts State Board of Health, concur in this conclusion that B. coli is not a normal inhabitant of either clams or oysters.

Investigations leading to the same general inference have been made in various laboratories abroad, among which may be mentioned those of Klein[67], Houston[68], and Hewlett[69].

In regard to numbers of bacteria contained in the alimentary canal of oysters, Herdman and Boyce[42] found from 0 to 5 in deep-sea oysters when testing on agar. Oysters from shops contained from 1 to 1200 on agar, and from 1700 to over 20,000 on sea-water gelatine.

LIFE OF TYPHOID FEVER GERMS IN LIVE OYSTERS IN SEA WATER.

Evidence upon this proposition has been obtained by several observers by putting oysters from unpolluted sources into small receptacles containing sea water infected with typhoid fever germs. From time to time examinations were made of the tissues, pallial cavity, alimentary tract, shell water, etc., of the oysters. All observers have found that these disease germs penetrate the oyster body and live there in gradually decreasing numbers for various periods ranging from about one week to one month. In no case has anyone observed any signs of multiplication of typhoid germs within a live healthy oyster.

The principal data upon this point are summarized in Table No. 6.

TABLE No. 6.

Investigator.	Date.	Period. Days.	Remarks.
Foote[40]	1895	30	Lived longer in oyster than in water.
Chantemesse[41]	1896	2	
Klein[41]	1896	17	No record of period of elimination.
Herdman&Boyce[42]	1899	14	Lived longer in water than in oyster.
Field[43]	1904	9	

In each case there is doubt about all of the typhoid germs having died within the period given; the records simply show the period up to the time when it was last observed.

Attention is called to the fact as noted in the table, under "Remarks," that the comparative longevity of the germ in the oyster and in the surrounding water differed with the different observers. Generally speaking, the life within the oyster was found to be very similar to that in sea water as shown in Table No. 5, and the remarks made in that connection are also applicable here.

Herdman and Boyce[42] made tests to ascertain how long a period was required in which to remove typhoid germs from infected oysters by subjecting them to a running stream of pure sea water. In seven days they found practically a total disappearance.

Field[43] found upon changing each day the infected oysters to a new clean tank of uninfected sea water that the specific germ within the oyster (and also clams) could not be found after four days.

In each of the latter tests it is to be noted that the period was about one-half of that observed where the oysters remained in the originally infected water.

As large numbers of typhoid germs were used in infecting the oysters in these tests, under conditions less favorable from a sanitary standpoint than ordinarily occurs in nature, these data show in this regard abnormally long periods of life. How far this aspect of the case goes to offset limitations in laboratory methods for the detection of the specific germ is a question which cannot now be decided.

LIFE OF TYPHOID FEVER GERMS IN DEAD OYSTERS.

Field[43] notes the result of some experiments in which he observed a well defined growth of typhoid fever germs in some

dead and dying oysters in sea water. These oysters were infected with enormous numbers of typhoid germs, and the conditions of the test would in this regard be rarely, if ever, duplicated in nature. The great mischief which could be done by one dead infected oyster among a lot of oysters suggests at once that this matter should be investigated most thoroughly.

This possibility of growth of typhoid germs on dead shellfish is accepted by Dr. Nevin[31] and mentioned in his testimony before the Royal Commission, but the evidence to support it seems to us to be very limited.

Klein[70] makes no mention of this question, but he records some observations indicating that the typhoid germ may multiply in cockles.

The question of growth of typhoid germs on cooked oysters, in instances where some, but not all, of a lot of infected oysters are killed by cooking in the same receptacle, is a matter worthy of serious consideration.

The antagonism[71] of other kinds of bacteria towards the typhoid germ is a very important matter in this connection, as it is quite possible that the ordinary kinds of bacteria present in an oyster at its death might normally prevent any appreciable growth of typhoid germs. The proposition from this standpoint certainly ought to be thoroughly studied.

RESISTANCE OF TYPHOID GERMS TO HEAT.

While typhoid germs form no spores and are killed by heat, it is not probable that heat as ordinarily applied in cooking oysters is nearly as great a safeguard against infection as is believed to be the case by many. Thus, Nevin[31] recognizes this in reviewing the data secured at Manchester, and Herdman and Boyce[42] advise that oysters should be *sufficiently cooked*, that is, raised to the boiling point and kept there for at least ten minutes. Clark and Gage[66] found that while exposure for five minutes to a temperature of 55° C. killed the great majority of typhoid germs, a few survived a temperature even of 80° C. In some interesting experiments made by Hill[72] it was found that the cooking of oysters, as ordinarily practiced, usually, but not invariably, killed typhoid germs.

An instructive report along this line of thought is that by Dr. Hamer[73] producing plausible evidence for attributing an out-

break of typhoid fever in certain districts of London, late in 1903, to *fried fish*. In Health Officer Murphy's letter of transmittal reference is made to similar outbreaks officially reported in 1898 by Health Officer Annes of Huddersfield, and in 1899 by Health Officer Williamson of Sandal Magna.

RELATIVE VITABILITY OF B. COLI AND B.TYPHOSUS IN WATER.

The longevity in water of these two species of bacteria is considered by bacteriologists to be quite similar. B. coli is believed by some to be slightly more hardy and to live a trifle longer[66] in water, although Houston[54] found B. coli only after seven or eight days upon making a test with pure sea water artificially infected wih B. coli.

So far as this feature is concerned, the prevalence of B. coli appears to form a satisfactory index for indicating pollution in shellfish and in the water surrounding them.

SANITARY CONDITION AS SHOWN BY INSPECTION OF BEDS AND FATTENING GROUNDS OF OYSTERS AND OTHER SHELLFISH.

During the past ten years it is safe to say that a majority of the more prominent oyster beds, fattening grounds, etc. in this country and elsewhere have been examined with considerable care either by official sanitary inspectors or by those who are competent to form a reliable general opinion as to their sanitary significance.

Similar attention has also been given to other shellfish, especially clams, the life history of which is more or less similar to that of the oyster. The reports of the Rhode Island Commissioners of Fisheries for 1899 and 1900 contain many interesting features about mode of growth, etc., of clams, particularly of the soft shell variety.

Sanitary conditions can be adequately decided upon when the surroundings obviously show either freedom from all pollution or when the sources in question are very seriously and objectionably polluted. Unfortunately, many oyster layings come within the intermediate class, generally spoken of as "doubtful;" and about which it is difficult to arrive at a correct and reliable opinion as to the probable degree of pollution on some occasions. Concerning this doubtful class it is to be stated that information should cover reliably a wide range of

conditions as to wind, weather, currents, and in general take into account all of the physical conditions both subjectively and objectively which bear a relation between population serving as a possible polluting factor and the body of water or beds serving for the cultivation of oysters or other shellfish.

Dr. Bulstrode in his classical report[11] "On Oyster Culture in Relation to Disease," published in 1896, presented the first comprehensive record of the condition of practically all the oyster layings of the English and Welsh coasts. In these sanitary surveys very careful attention was paid to the various physical factors involved in the premises, and which taken collectively record in full what the English sanitarians speak of as the "topographical conditions." Numerous maps were included in Dr. Bulstrode's report to facilitate an understanding of the actual conditions found. To appreciate fully the contents of this excellent report it is necessary to refer to the original. Here it is sufficient to say that many of the oyster layings were in such sanitary surroundings as to make it obvious to the investigator that the oysters and water from these sources were not of a perfectly safe hygienic character.

The State Board of Health of Massachusetts for the past five years has been giving much attention to this question. The report of these investigations, bearing directly and indirectly on all phases of this matter, has not yet been published. It is of interest, however, to note that in connection with some of the bacteriological reports[66] they separate the sources from which shellfish were taken into the three general classes as above mentioned, and that the polluted and doubtful sources form a substantial proportion of the total, as indicated by the following table:

TABLE No. 7.

	Number of Sources.	
Character of source.	Shellfish.	Sea Water.
Not polluted	15	10
Doubtful	22	19
Polluted	6	4

An idea of the location of these several classes of sources is indicated in a special report[74] of the Board to the Massachusetts Legislature in May, 1902.

The oysters taken from the Providence River and Narragansett Bay, below the city of Providence, R. I., have been studied

by Dr. C. A. Fuller[75], who has found that there are several oyster beds within a comparatively short distance of the outfall discharging the sewage effluent from the chemical precipitation works of the city of Providence.

Reference has already been made to the former pollution existing in the fattening beds in the neighborhood of Atlantic City, N. J., but which unsanitary conditions were corrected by order of the City Board of Health[26] several years ago.

Dr. Brown[76], Medical Inspector of the Local Government Board of Ireland, has made a comprehensive report upon all of the principal oyster layings on the Irish coast. This important work was done along lines similar to that by Dr. Bulstrode. In general it may be said that a considerable number of the principal oyster layings showed objectionable sanitary conditions with reference to possible or probable sewage pollution.

Dr. Bensel, Sanitary Inspector of the Board of Health of the city of New York, records[33] the fact that many of the oysters taken from the general vicinity of New York City come from unsanitary sources, referring more particularly, however, to the floats and houses in which the oysters are bloated and bleached.

Reference has already been made to the contamination of portions of Jamaica Bay[27] in the vicinity of Lawrence, L. I.

In regard to the Great South Bay, on the southern coast of Long Island, from which the so-called "Blue Point" oysters come principally, the last report[77] of the U. S. Fish Commissioner records opportunities for pollution, especially in the floats near shore, although the oysters actually analyzed were free from sewage pollution.

In the recent report[78] to the New York Legislature of the New York Bay Pollution Commission it is stated that about 1,000,000 bushels of market oysters and clams are taken annually from the lower New York Bay (below the Narrows) almost exclusively from Gravesend Bay (Kings County) and the southeast side of Staten Island (Richmond County). These shellfish, valued at about $900,000 annually, consist largely of oysters taken from private areas. The industry appears to be increasing, as the extent above stated is 30% to 40% greater than that given for 1901 in the report[79] of the U. S. Fish Commission. The New York Bay Pollution Commission speaks of the present pollution of the Bay as distinctly measurable,

although not great; and further states that most of these shellfish beds are free from dangerous pollution, though some of them are found to be nearer sewer outfalls than is wise or proper This commission also adds that analytical data show the water from the "drinking grounds" to be more polluted than that from the natural beds.

BACTERIOLOGY OF COMMERCIAL SHELLFISH AND ASSOCIATED WATERS.

Although much work has been done upon this subject, the evidence has not yet become clearly enough crystallized so that bacteriological data by themselves can be utilized practically by sanitary authorities in securing a better control of the shellfish placed upon the market.

At the outset it is necessary to consider that the oysters and other shellfish are not cultivated at long distances from the coast where the waters are comparatively pure, as already indicated, but that they are grown comparatively near the shore at depths which enable them to be dredged, and where food is also available for their growth. This is especially true of the drinking grounds where they are bloated and bleached.

The evidence seems to be quite conclusive that oysters grow and fatten more readily in sewage polluted water than they do in pure water, with its relatively sparse organic food.

Data are available in numerous instances showing the effect of sewage discharged under conditions where the pollution is so great that the oysters and other shellfish should not be cultivated there. But the evidence is very meagre in showing precisely what slight amounts of sewage, if any, may reach waters in the vicinity of oyster layings and at the same time allow the oysters to be of satisfactory sanitary quality at all times.

From what has already been said it is apparent that sewage bacteria (including typhoid fever germs) disappear quite rapidly after their entrance into large bodies of water. This point is illustrated by the following table, showing the comparative numbers of bacteria at different distances from one of the two principal outlets in Boston Harbor for the discharge of the sewage of the metropolitan district of Boston[80].

TABLE No. 8.

Distance from Deer Island Outlet.	Bacteria per cubic centimeter.
0 (at outlet)	2,240,000
500 feet	121,000
1000 "	35,000
3000 "	1,800

Even more instructive and interesting are the records given in the next table, from Prof. Clowes' report[81] to the London County Council, showing the rapid disappearance of the great majority of the sewage bacteria entering the lower tidal estuary of the Thames below the sewage precipitation works of the metropolitan district of London. Shortly after the open sea near Nore Light is reached it is seen that the numbers become comparatively very low, approximating those found in the German Ocean. This observation is still more interesting by virtue of the fact that in the Barrow Deep, about fifteen to twenty miles from the Nore Light, there are discharged on an average each day about 7,000 tons of sludge taken from the London sewage works, each cubic centimeter of which contains about 130,000,000 bacteria.

TABLE No. 9.

Locality.	Distance from Crossness (miles).	Bacteria per cubic centimeter.
(Effluent of sewage works)	.0	7,442,857
Mucking light	21.3	4,837
Mole Haven	24.3	3,431
Chapman light	27.0	1,662
Yonklet Creek	29.5	711
Southend pier	31.5	379
Garrison Point	33.5	381
Nore light	35.8	186
Below the Nore	39.3	145

It is needless here to record in much detail the analytical results of the several thousands of oysters and other shellfish which have been examined bacteriologically in various laboratories, especially those in Great Britain and in the United States. In brief it may be said, as already mentioned, that the results of bacteriological analyses show very satisfactory confirmation of the results of careful sanitary surveys of existing local conditions when those conditions show clearly either the absence of pollution or the presence of well-defined pollution.

In regard to the intermediate class, where pollution is doubtful, the bacteriological evidence is of importance and in

general the analytical data are in harmony with the results of sanitary surveys. This is not always true, however, as in some instances, particularly in such exhaustive observations as those made by Dr. Houston[68] in England and by Prof. MacWeeney[76] in Ireland. It was found that occasionally bacteriological data were interpreted on too rigid lines, and in other instances they gave a clue to polluting factors which were not noted during inspection.

Speaking generally, it is of interest to quote from Prof. Houston's report[68], that "experiments show that B. coli or coli-like microbes can not only be practically always isolated from a mixture of ten oysters derived from layings which, judged from the topographical point of view, would be considered either above suspicion or at least remarkably clear from pollution; but also that such microbes can easily be isolated from each individual, or at all events in a great majority of the ten oysters experimentally tested." Thus it is seen that the oysters are quite generally grown in England under conditions where some intestinal bacteria are present, and it becomes necessary to measure the sanitary significance of the numerical contents of B. coli in the oysters, and also the relative value of allied factors in order to arrive at the degree of probable pollution.

Huston's[68] quantitative analyses indicated that oysters taken from various layings contained numbers of B. coli or coli-like microbes ranging from 10 to 1000 to each oyster, the volume of which varies ordinarily is from about 10 to 15 cubic centimeters. He found that the contents of the stomach were more likely to show the presence of B. coli that the shell water, which may bear a direct relation to the water surrounding the bed at the time of removing the oyster. For this reason it seems desirable to cut up the oyster and test the entire liquid which flows or oozes from the shell and body. He suggests two provisional standards, one of which he calls a lenient standard and the other a stringent one; by the former he considers as polluted an oyster containing more than 100 B. coli or coli-like microbes per oyster, and by the latter he puts the limit at 10 per oyster. The Royal Commission[28] in summarizing the results states that future data are required before accepting any standards which would justify condemnation.

One feature has come out very prominently, and that is that the test for B. coli should be made very thoroughly[68] to establish their indentity[76] with those coming from the intestines of men and animals, and that these tests should not be allowed to rest on partial[66] or presumptive[78] laboratory[53] data[39].

A very valuable and instructive set of observations on the bacteriology of oysters from polluted sources recently published by the United States Fish Bureau, is that by Prof. C. A. Fuller[82], who found in the Narragansett Bay that the B. coli contents of oysters gradually lessened as the distance increased from the outfall of the Providence sewage precipitation works, and that there were no observed B. coli in oysters eight miles or more distant from the outfall and away from the source of pollution. This paper also contains a very well prepared review of the literature on "oyster infection."

POLLUTION ON THE OUTSIDE OF OYSTERS.

Naturally there is much sediment including bacteria which is deposited from the water on to the beds in which oysters and other shellfish grow. From the sanitary standpoint it is significant that in the investigation of the outbreak of typhoid fever at Lawrence, L. I.[27], Dr. Soper found by analysis that while 20% of the oysters were certainly polluted on the inside, as many as 70% were polluted on the outside of the shell. The widespread significance of this is that as the oysters are placed on the market, polluting material from the shells of a few oysters very likely, under some circumstances, might seriously pollute oysters which otherwise were perfectly safe. Whether or not this is generally true, or applicable only to the particular conditions in question needs further careful study.

RELAYING OF OYSTERS.

For many years it has been the custom in France to relay oysters in disgorging tanks for a short time with the view to causing the disappearance of pathogenic bacteria before the oysters are placed on the market. This proposition was investigated in 1895 by Professors Herdman and Boyce[83], and as a result of their observations they recommended that before the oysters are placed on the market they should be allowed to remain for a short time in water of unsuspected and well es-

tablished purity. There is unquestionably much merit in this proposition, as was testified to by a large number of competent observers in the hearings held by the Royal Commission on Sewage Disposal. As to the period of time required for polluted oysters to free themselves from all objectionable bacteria, the evidence is not conclusive. Most observers think that it would be safe to make the period two weeks, while a few prefer a period of three or even four weeks. The experts for the Royal Commission, however, at the time the last report of the Commission was published had made comparatively few experiments. Taking everything into consideration, the Royal Commission[25], while recognizing the importance of the relaying of shellfish, not only from the point of view of public health but also from that of the oyster trade, did not feel disposed to committing themselves upon the practicability of the method, but strongly recommended further investigation of the matter.

SUMMARY.

Effects of Pollution.—There seems to be no room for doubt about typhoid fever and other intestinal diseases being produced to a limited degree by oysters and other shellfish taken from polluted waters. While some of the evidence is not above question and the data are extremely meagre for basing an opinion as to the effect of polluted shellfish upon the general prevalence of typhoid fever either upon a single community or upon a whole country, yet the English studies show that it is material and sufficient to call forth more study for means of prevention. Those who do not recognize any relation between pollution of shellfish and the causation of disease either have not looked into the matter or have biased views for commercial reasons, although it was recently rumored[84] in this country that a French commission had reached the conclusion that oysters could not transmit typhoid fever. Regarding this reference to the French commission, coming by way of consular reports, it is found upon consulting the original reference[85] that Prof. Giard's report is sound and conservative, according to general evidence. He concludes that typhoid fever may be transmitted by polluted oysters, although he believes that some of the cited cases are based on questionable evidence. He also states

that the bacterial diseases of the oyster are not transmitted to man.

Oyster Cultivation in Grossly Polluted Waters.—There is absolutely no room for doubt about this being an unsanitary condition of affairs, and one which in the interest of all concerned should be prohibited by law, with proper authorities placed in a position to see to it that this practice is not allowed to continue.

Shellfish Cultivation in Unpolluted Waters.—As a considerable portion of the oysters cultivated in this country come from beds which are practically above suspicion on hygienic grounds, the interests both of the consumer and of the trade require that such sources should be accurately and honestly certified to in a manner similar to "certified milk farms," and by authorities whose technical ability and honesty are above question. The technical advisers of such authorities should be thoroughly trained in engineering, chemistry and biology in all of the various applications to water pollution as associated with the shellfish industry.

Shellfish Cultivation in Moderately or Slightly Polluted Waters.—This is the most difficult by far of the various conditions which should confront suitable authorities, as, from what has already been said, it is out of question to base an adequate opinion upon a single inspection or upon a limited number of analyses, on account of such data not being representative of all conditions met with, and therefore perhaps misleading to a serious degree. Improved methods of study of this problem are very urgently needed, and the results of such improved methods should be applied most exhaustively in order that this matter may be clearly put on a basis fair to the consumer and fair to the oyster trade. One of the principal topics requiring thorough study is the practicability of relaying oysters coming from slightly polluted sources in pure water under such conditions and for such a period of time that the objectionable bacteria may be certainly eliminated.

Relation of Shellfish Pollution to Sewage Disposal Problems.—This matter has not yet been considered other than in a superficial way in this country, but it is clear that the time is approaching when the relative aspects of these matters must be carefully weigned. Speaking generally, it seems apparent[86] that where small sewage disposal projects are associated with large shell-

fish industries, the latter as a business proposition should not be injured or destroyed when a relatively small sum of money produces a satisfactory purification of the sewage. On the other hand, where the sewage disposal question involves a very large center of population and its corresponding cost for purification beyond the point of preventing gross nuisances, then it seems that the small shellfish industry should become subservient to the larger public interests, and be abolished. Where the relative money values of the shellfish industry and of the sewage disposal question approximate each other, it becomes a matter for careful consideration and adjustment for each locality.

Nature of Supervising Sanitary Authority.—In this country the question of polluted shellfish rests largely with the local Boards of Health, who have the authority to prohibit the sale of such food within their city limits. Naturally there are not many boards equipped with technical facilities to do much with this question. State Boards of Health when directly authorized by special legislation may take up the matter on broader lines, as in the case of Massachusetts. The general supervision of the shellfish industry in the United States, however, comes within the jurisdiction of the State Fish Commissions, who as yet have done very little with sanitary matters. To handle the matter adequately, it is obvious that further legislation is required, and differing, quite likely, in different states.

Much interesting discussion on this matter is contained in the fourth report of the Royal Commission on Sewage Disposal, which recommends a new central authority, thoroughly equipped to take up all phases of this matter in Great Britain, and which in turn along executive lines would work through the local River Boards.

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DISCUSSION.

DR. GEORGE A. SOPER.—MR. Fuller's paper is regarded by the speaker as the most valuable digest which has appeared concerning an important aspect of the oyster-typhoid question. Among its several objects, it seeks to answer the question, Are shellfish liable to be the carriers of typhoid germs, and if so, under what circumstances? Mr. Fuller's answer is the answer of every sanitary expert who has given intelligent study to the matter; shellfish which are grown or temporarily immersed in sewage-polluted water undoubtedly are at times the bearers of the infectious virus of typhoid fever.

How much sickness is due to shellfish infected by sewage and just what steps should be taken to prevent the spread of typhoid in this manner, are matters upon which Mr. Fuller has not attempted to express a definite and final opinion. He has given the most important facts, taken from scientific investiga-

tions into the conditions under which shellfish may become infected, but he has left it largely to others to propose the practical means by which the sanitary evils which exist may be corrected, stating merely the unassailable position that, when a discharge of sewage threatens to pollute oysters intended for market, either the oysters or the sewage must be taken care of in such a way as will not permit of their coming together.

Being so largely a compilation of well established facts, most of the paper affords little debatable ground. As a whole, however, it gives an excellent starting point for a discussion of the principles, plans and policies which should underlie work for the prevention of typhoid through shellfish, and it is in directing his remarks to this aspect of the subject that the writer believes he may most usefully contribute to the discussion. The suggestions made are not offered as a solution of all the difficulties attending the subject, but they are presented with the object of eliciting free discussion.

The amount of typhoid fever which is caused throughout the country by infected shellfish is not even approximately known. Statistics do not show that there is an unusually large amount of typhoid in localities where it would be expected if polluted shellfish were a very prolific cause of disease. The typhoid death rate for most of the large sea-board States and for the Middle Atlantic States are comparatively low.

At the same time, it must be remembered that statistics are a poor guide to the prevalence of typhoid fever under any circumstances. There is always more of this disease than is reported. The total number of cases of typhoid which may exist may be manyfold the number officially known to the health authorities. It is one of the leading defects of our public health administrations that typhoid fever is reported neither accurately nor promptly.

It is unfortunately a fact that the causes of most cases of typhoid are not satisfactorily traced, so that even if every case were officially reported, it would be impossible for us to know how many were attributable to shellfish. The greatest laxity in this direction exists with respect to sporadic or scattered cases of typhoid fever, and it is precisely this type which is usually produced by infected shellfish.

Notwithstanding these defects of statistics, however, there

seems reason to suppose that the largest consumers of oysters, the oystermen themselves, suffer more than most persons from typhoid fever. According to the United States Census of 1900, the typhoid fever death rate, reckoned on the basis of one hundred thousand population, is high among men collectively grouped as sailors, pilots, fishermen and oystermen.

The reported death rate in this class for 1900 was 67, as compared with a rate of 38.8 for the total population in the registered areas of the United States. Too much reliance should not be placed upon these figures, however, since there is considerable difference in the habits of the several members of this group and they may all be exposed to typhoid for an unusual extent in other ways. Cases of typhoid fever have been seen repeatedly by the writer among oystermen and their families under circumstances which left no room to doubt that infected shellfish have been the cause.

Owing to their wide distribution, it is not likely that the infectious nature of shellfish from any locality is often discovered. In an investigation of an outbreak of typhoid fever in the vicinity of Lawrence, N. Y., in 1904, it was found that the local consumption of oysters, from certain infected grounds and storage places in the vicinity, was about one-half of one per cent. of the total output from that district. The local consumption gave rise to twenty-one cases of typhoid fever. The oysters which produced the local outbreak were apparently fair samples of the larger quantity which was shipped off. From this it would appear that several thousand cases of typhoid fever may have been caused among the consumers of the shellfish which were sent away. Commenting on the possibility that a large number of typhoid fever cases may have been caused by the consumption of infected shellfish from this vicinity, the official report of the investigation of the outbreak says: "At first sight, one might think that so much typhoid fever from a single cause would promptly lead to the discovery of that cause. Further thought, however, shows that this would not be likely. Several thousand cases of typhoid could easily occur without drawing suspicion to these oysters and clams. The shellfish from this source are shipped to widely separated points—some are said to go to Enrope. Three or four thousand cases of typhoid , scattered among so many people over so

large an area at a season when typhoid is expected to be more or less prevalent, would scarcely attract attention."

It is not believed by the writer that this number was actually attacked, but that many more suffered than were known seems extremely probable.

The number of cases of typhoid known to be annually produced by oysters or clams in any vicinity, even though very small, should not be considered as the measure of the need of protecting the purity of the shellfish. No known cause is too insignificant to call for removal.

It is unfortunate that there is no way by which a consumer can infallibly tell whether raw oysters which are placed before him are infected or not. The writer has seen polluted shellfish which bore every appearance of being wholesome. Experts can sometimes tell by the appearance of the shell whether an oyster has been grown upon a hard or soft bottom or in shallow or deep water, but there is no easy tell-tale of pollution which can be relied on.

Nor is any measure of precaution which can be taken at the table capable of rendering infected oysters innocuous. Tomato catsup, horse radish, lemon, red pepper, and other condiments which are often used upon oysters are not capable of destroying the germs of typhoid fever, when present. The writer has seen a case of typhoid which was produced by oysters eaten in the form of an oyster cocktail. It is necessary to cook an oyster thoroughly in order to destroy its harmful properties.

Apparently, protection from typhoid fever through shellfish must lie chiefly with the Board of Health, State Commissions in charge of the shellfish industries, and with the oystermen themselves. The nature of the regulation possible by Boards of Health has been a question of debate in some quarters. In the writer's view, it should be possible for a local Board of Health to control the purity of the oyster supplies in much the same way that the purity of milk supplies can be controlled. Local boards act under special sanitary ordinances, or general health laws, which give them authority to seize and destroy unwholesome food, and there appears to be no reason why this legal authority should not be used advantageously in controlling the quality of shellfish. There would only be the need of providing that a given lot of shellfish were unwholesome to give the local board

ample power to destroy them or prohibit their sale. The difficulty here would be to prove that the shellfish were unwholesome.

Mr. Fuller has suggested tests by which the purity of oysters can be determined. In the hands of experts, these should prove of much value, but there are limitations to their use. By the time that a lot of shellfish which are suspected of having been the cause of typhoid fever can be subjected to analysis, from two to three weeks will in all probability elapse from the date of infection, during which period the germs are likely to disappear,—if, in fact, any of the original oysters can be found and examined. Furthermore, local Boards of Health, except in municipalities of considerable size, are not equipped for bacteriological work or do not know how to make arrangements for having it done.

Where cases of typhoid fever are traced to shellfish from a given community, suspicion may well attach to that source in the future, unless there is excellent reason to suppose that proper preventive measures are taken. Such sources should be constantly watched. The taking of shellfish from places known to be polluted should be prohibited.

In coming to a decision as to the probability of pollution, the writer is much impressed with the value of a competent inspection of the sanitary conditions under which the oysters are produced. In an investigation of the shellfish grounds situated throughout the entire length of the Irish coast, Profs. T. J. Brown and E. J. McWeeney* found that the value of a sanitary inspection of the source of shellfish and careful bacteriological analyses of them were about equal. In a large majority of instances, there is no difficulty in ascertaining whether producing grounds, storage places or drinking places are polluted.

It might seem that another way in which local boards could control the purity of shellfish would be by restrictions placed upon the production and handling of shellfish intended for shipment for consumption at distant points; but here we meet with the necessity for sanitary control under circumstances which would probably not appear to be sufficiently imminent and pressing to the local board to insure its action. Sanitary restrictions of the kind necessary might conflict with a profitable

*Report of Local Government Board for Ireland, 1903.

local enterprise, in which event, the local board would find it difficult to enforce the preventive measures demanded.

So far, no way has been found for the National Government to control the purity of shellfish, and desirable as this form of regulation appears from some standpoints, it does not seem likely that it will soon be brought about.

In the writer's view, the State Board of Health is the proper authority to control the sanitary conditions of shellfish production. In Massachusetts, the State Board of Health has, as we are informed, shown an active interest in this subject and the action which it took in 1904, in connection with the production of shellfish from New Bedford Harbor, shows what can be done in this manner. Finding that shellfish taken from certain sections of the harbor of New Bedford were apt to be polluted with sewage, the State Board of Health requested that branch of the state government which has supervision over shellfish, the Commissioners of Fisheries and Game, to prohibit the further digging of shellfish from the affected areas. This request was acceded to. The fishermen were warned that after a certain date it would be illegal to take clams from a section of the harbor which was definitely described. Immediately following this, there was a marked falling off in the number of shellfish diggers, but they soon returned. Thereupon, on August 29 and 31, 1904, the Commissioners of Fisheries and Game caused the arrest and conviction of twenty-six men for digging shellfish within this area, after which there seems to have been no difficulty in restricting the production from polluted grounds.*

The suggestion made by the Royal Commission on Sewage disposal,† that all beds and storage places be licensed and that dealers be restricted by law from selling oysters from any but licensed places, seems to be an excellent one. There is no obvious reason why some such plan should not be followed in some sections of the American coast, at least, under the jurisdiction of the various shellfish commissions assisted by the State Boards of Health.

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*Annual Report of the Commissioners of Fisheries and Game, Massachusetts, 1904.

†Fourth Report Royal Commission on Sewage Disposal.

Although some have thought that a further examination of this subject might show the necessity of extensive sewage purification systems and the diversion of sewage from municipalities to points remote from centers of shellfish industries, the writer considers that in most cases it will be the oyster business and not the sewage which will require to be removed. In some cases it will be difficult to decide between the two.

The most promising outlook for the initiation of better sanitary conditions in the oyster business lies, in the writer's view, in the hope that the fishermen themselves will soon appreciate the need of affording their customers protection from the small but unnecessary danger of typhoid to which they are now exposed. It would seem to be a distinctly desirable business proposition for the oyster growers voluntarily to avoid polluted waters, and to place upon the market shellfish which can, by every test, be shown to be pure. If an oyster scare should then occur, a fortune would await the oysterman who could afford to call public attention to the sanitary ways in which his oysters were produced and marketed.

Dr. Henry Leffmann.—I desire to express my personal thanks to Mr. Fuller for this timely and well-prepared paper. It is a most valuable summary of the trustworthy data on a topic of great importance in practical hygiene, and one to which public attention has not been much directed. Experience has fully demonstrated the large part that raw foods play in the distribution of disease. Water, milk, fresh vegetables and shellfish are largely consumed raw and are all common and frequent sources of disease. The general indifference of even intellignt members of the community to these dangers is noticeable, and it will only be by such papers as Mr. Fuller's that an awakened interest will bring about reforms. Even with this progaganda, I fear that more such sad experience will be needed before the reforms will be thorough and far-reaching.

I have had, through the courtesy of the author and the interest of the Secretary of the Institute, an opportunity to see the proof of the paper, and am, therefore, familiar with many of the details that the author merely outlined or suggested in his remarks this evening.

I had an opportunity through the courtesy of the special

committee appointed by the Atlantic City Academy of Medicine, to examine, in company with Dr. A. C. Abbott, the circumstances under which typhoid fever was distributed by oysters in Atlantic City in 1902. The committee worked out the facts thoroughly, and Dr. Abbott and myself were pleased to endorse its view.

Briefly, I may say that, in this case, the oysters were placed in a crib that was located near the junction of the Beach Thoroughfare with an artificial channel termed the Penrose canal. The object of this canal was to cut off some of the winding portion of the natural channel. The sewage of the city is emptied into the Thoroughfare by a pipe that crossed this canal. During the summer this pipe broke in such a manner as to cause the sewage to leak into the channel and to be swept by the alternating tidal currents back and forth through the crib, The oysters were thus soaking constantly in the sewage-polluted water. Raw oysters are largely consumed in Atlantic City during the summer months.

The result of this was that the city, which up to that time had been but little troubled with typhoid fever, began to show a sharp increase in the number of cases. The active practitioners became alarmed, and at once instituted a searching inquiry. In this they fortunately had the active assistance of some of the local authorities and of the more influential hotel-keepers. It was, of course, appreciated that if the disease became well established the city would be seriously injured in its popularity as a summer resort. The physicians and business men of the city deserve great credit for their prompt acknowledgment of the seriousness of the question, their frank statement of the facts, and their concerted action to prevent recurrence of the trouble.

Concerning general preventive measures I have little to say. The problem is more complex in this country than many others because of the absurd and unscientific system of administration by State government. If ours were a national instead of a federal republic, more could be done. As it is, the jealousies of States prevent concerted action. Petty local pride often sets bounds to reform. I had good occasion to note this when I was a member of the Pennsylvania Quarantine Commission. Very little in the way of reform in the control of food adulteration, water supply, and other matters of public hygiene

can be done until the powers of the general government are extended. Fortunately, the tendency is largely in this direction. The present national administration shows a stronger tendency to centralization than any that has yet been in power, and while this tendency may receive temporary checks, the main evolution will go on.

Papers such as this presented to-night will have far-reaching educational value. I am, however, not hopeful that the oystermen or the oyster purveyors will be very alert in supporting reform measures. I may also say that as far as regards the statistics given this evening, which seem to show a higher death rate from typhoid fever among sailors and watermen, this may be due largely to the practice of these persons in drinking polluted river water and not to eating oysters.

MR. KENNETH ALLEN.—It is not many years since the derivation of typhoid from infected shellfish has been recognized. In Constantinople it was observed by physicians that much of the typhoid brought to their notice among the better classes was associated with the eating of oysters, and on examination these were found to contain the typhoid bacillus. During the past few years there have been a number of typhoid epidemics traced directly not only to infected oysters but to cockles, mussels and clams, and the subject has received close study in France, England and the United States.

The more important facts that appear to be fairly well established are:

1. That the typhoid bacillus is gradually crowded out by the much more numerous saprophytes in grossly polluted waters.

2. That it does not survive at a temperature much below blood heat.

3. That it may live for weeks in sea water.

4. That it tends to die out when taken into the oyster and is eliminated within a few days when placed in clean water.

Oysters taken from a polluted water retain typhoid bacilli longer if kept in the air than in clean water, and are less capable of disposing of them in case of further infection.

The colon bacillus, however, has been observed by Prof. Kline, of England, to disappear rapidly in oysters kept either in air or water. He also found that mussels and cockles, which are relatively important as a food supply abroad, were less ca-

pable of disposing of the typhoid germ, this being found actually to multiply in them at first.

These facts would indicate that the particular danger of infection in the case of oysters is confined to those cases where these are taken from grossly polluted waters—as in the vicinity of sewer outfalls—and eaten raw; and this view is confirmed by the various investigations of cases of infection that have been made here and abroad.

Oysters taken from their natural beds, except near towns, are not often to be suspected; but the general custom of storing and fattening oysters in artificial layings, which are frequently in the vicinity of sewer outlets, should be condemned severely. In an epidemic of typhoid at Lawrence, L. I., last year, Dr. Soper examined ten oysters from various storage floats and found B. coli in 10 cc. in every case. Out of thirty-one cases, over half were directly traced to eating infected shellfish, while the indications were that all originated in this way.

Oysters are taken for the market from the greater length of our sea coast, and with increasing population the protection of this food supply should receive more attention than in the past. The waters of Providence River, Long Island Sound, and Staten Island are noted for their oysters, while receiving the waste products of several million people. The Chesapeake Bay, too, noted for its oysters, receives the sewage of Harrisburg, Baltimore, Washington and other cities, although it should be born in mind that here the populous centers are more remote, and while the oysters are taken from the various bays and estuaries, the discharge from the Susquehanna, Patapsco and Potomac Rivers tends to follow the deeper channel of the Bay.

As it is impracticable to prevent the pollution of water courses near cities the obvious remedy is to prohibit the taking of shellfish from within certain limits that may be defined by the State Boards of Health.

This has been done by the local board in the case of Beach Thoroughfare, Atlantic City, where formerly oysters were fattened for the market. A typhoid epidemic in the fall of 1902 called attention to this fact, resulting in an investigation by the Academy of Medicine, assisted by Drs. Abbott and Leffmann, of

this city. The practice of selling these for the local market has been stopped, but it has been found impracticable to prevent their shipment to cities outside the State.

This brings up the question of inter-state action or control by the Federal authorities. From the fact that 20,000 bushels of oysters and 5,240,000 clams were shipped from this market in 1903, the magnitude of the danger is evident, and the mere suggestion, mentioned by Mr. Fuller, that 10 per cent. of the typhoid deaths in London and Manchester may be due to eating infected shellfish should be sufficient to bring about measures to remedy present dangerous conditions.

Mr. W. H. Clark (Correspondence).—The pollution of shellfish by sewage has, during the past few years, become generally recognized as a subject of much importance, both from the commercial and hygienic point of view. Pollution of this sort and its effect in causing typhoid fever began to be recognized many years ago, as pointed out in Mr. Fuller's paper, but only a small amount of systematic study of the subject has been made until during the past few years. In Masachusetts, while the shellfish industries are of small moment from a commercial standpoint when compared with these industries in other States, the consumption of native shellfish and also of shellfish brought into our markets from other States is very large, and it is evidently of the utmost importance to the people of the State that these shellfish, especially those eaten in the raw condition, be as free from bacteria foreign to themselves as sanitary precautions and laws can make them. As stated by Mr. Fuller's article, a quite extended investigation of this subject has been carried on by the Massachusetts Board of Health during the past few years and most valuable data have been accumulated. In this work not only has the pollution of shellfish areas been carefully studied, but also such questions as the life of sewage bacteria in sea water, the life of sewage bacteria in the shellwater of the shellfish and the life of sewage bacteria in or upon the body of the shellfish when kept under market or other conditions have also been examined into. Besides this, studies of the destruction of the bacteria by the common methods of cooking have been investigated. In the course of this work practically all the shellfish areas of the State have

been examined, nearly 2,000 samples of shellfish from these areas, and shellfish brought into the State from other sections have been tested, and also about 600 samples of sea water examined as an aid in the study of the subject.

As this work is still being continued and no official publication has as yet been made by the Board—with the exception of the communication to the State Legislature in May, 1902,—it is obviously expedient to enter into and explain its details and results here. Enough has been done, however, by us, to show the importance of the subject, the marked pollution of certain shellfish areas, to illustrate clearly the danger of eating raw shellfish from polluted sources and to show the inadequacy of some of the common methods of cooking shellfish to assure complete destruction of pathogenic organism. The work has also shown that shellfish kept under market conditions may be a source of danger to their consumers for many days after collection from the shellfish areas. In several instances the Board has prohibited the collection of shellfish from limited areas within the State, and undoubtedly much more work of this kind will ensue.

Mr. Wm. H. Park (Correspondence).—I have carefully gone over the paper that you are to read in Philadelphia, and agree entirely with your conclusions. From the little work we have done in New York, it seems to me that there can be no question that oysters are capable of communicating typhoid fever. To estimate the number of cases due to oysters is a very difficult, if not impossible, task. Personally, I think the actual number of cases is comparatively small. The danger, however, of such infection is constantly increasing, as the streams in which the oysters are placed become more and more polluted. We are thinking of having all oyster dealers take out a license and compelling them to designate from what places their oysters come. We then hope gradually to inspect the oyster beds and fresh water streams and allow only those to be used which appear to be fairly safe. It seems to me that the dealers themselves should combine in such a way as to make certain that all oysters sold by them are safe. At present a great many people refuse to eat oysters because of their fear of infection. The increased trouble which dealers would assume in getting oys-

ters only from safe places would be more than paid for by the increased sale of oysters known to be safe.

[NOTE BY EDITOR.—Dr. Edward Goldsmith has suggested to the editor that the judicious use of copper sulphate, in extremely minute doses, in the waters of the fattening beds, might wholly eliminate the danger of typhoid infection from the source above discussed.]

A NEW ULTRA-VIOLET MERCURY LAMP.

In addition to the visible radiation, all light contains also dark rays, not perceptible to the eye. These are known either as ultra-red or heat rays if their wave length is greater than that of visible light, or as ultra-violet, actinic, or chemical rays, when of shorter wave length than the visible spectrum. Within the last ten or twenty years, the development of physics and medicine has disclosed certain properties of this form of radiant energy, which are not only highly interesting from the point of view of pure science, but seem calculated to be of great service to mankind. In consequence, the demand has arisen for a practical and comparatively cheap form of apparatus for producing these ultra-violet rays, or as we may term them briefly, "uviol" rays.

The want has been supplied by a modification of the Hewitt mercury vapor lamp, the walls of which are made of a special glass prepared in the works of Dr. E. Yschimmer in Jena.

The new lamp consists of a tube of suitable shape—usually straight—made of special glass transparent to uviol rays, 8 to 30 millimeters in diameter and 20 to 130 centimeters long. Platinum terminals are fused in through the glass at the two ends, and are tipped with carbon knobs, so that each pole may be used either as a positive or as a negative pole. The lamp contains 50 to 150 grams of mercury, according to its size. This mercury not only furnishes the vapor necessary for the working of the lamp, but also serves for starting the luminous discharge and for cooling the negative pole. The dimensions are so calculated that the lamp can be connected up to leads of the usual tension of 220 or 110 volts without undue loss of current.

To light the lamp, it is not enough simply to connect it to the leads, the two poles must be for an instant joined by means of the mercury in the lamp, which for this purpose is tilted so as to allow the metal to flow from the one to the other. When once the discharge is started, it will continue after the mercury has fallen back to its normal position. The lamp being made with carbon poles, the ignition may be effected from the positive to the negative end, or *vice versa*, without injury to the lamp (through disintegration or fusion of the platinum terminals); the negative pole may even be laid bare for several seconds without harm while the lamp is being lighted. When, however, it is to run for a prolonged period, it is imperative that the negative pole be immersed in mercury.—Dr. O. Schott, in *Scientific American Supplement.*

The Adulteration of Foods.*

By C. B. Cochran.

State Chemist to the Pure Food Commissioner of Pennsylvania.

[The lecturer discusses the efficiency of the laws in force in the State of Pennsylvania to insure the public against harmful adulteration.—The Editor.

Less than half a century ago almost the entire population of this country lived upon food that was home-grown and home-prepared. With the exception of a few articles requiring a different climate that our own for their production, such as coffee, tea, sugar, spices and chocolate, the inhabitants of the country lived exclusively upon food of their own producing, while the dealers of the city were supplied with the products of the neighboring farms. Provisions of all kinds were supplied in an unprepared condition and their preservation or preparation for the table was acomplished at the home.

Nearly everyone was personally acquainted with the various manufacturing operations necessary, not only for the proper preservation of the products of the farm, but also for the converting of these products into a variety of articles of food ready for use. Even the products of foreign lands were prepared for use at the home. For example, spices were home-ground and coffee home-roasted.

At that time there was little need for laws regulating the sale of foods, for the opportunities for adulterating on the part of the seller were limited to a very few articles. Moreover, the methods of adulteration had not then been learnd.

With the advance of civilization and the specialization of industries, the preparation of our foods has gradually passed out of the home and into the hands of manufacturers. At the present time, this transfer from home to factory, while not yet complete in its details, is nevertheless so universal that it is felt to a greater or less extent in every household, no matter whether that household represents wealth or poverty, or whether located in city or country.

*A lecture delivered before the Franklin Institute in Association Hall, Friday, February 10th, 1905.

While this change has brought with it many comforts, and has rendered home life less burdensome and more enjoyable, it has also robbed us of that sense of security in the purity and cleanliness of our foods, which was so greatly appreciated and highly prized by our grandparents.

They in their time lived perhaps even more generously than we of the present, and took pride not only in setting a well-spread table, loaded with finely-prepared foods, but also in the fact that those foods were home-grown and home-prepared.

The housewife of a generation ago was mistress supreme of the culinary art. She found her life's work in the management of her home and the care of food materials, and their preparation for the table formed a large part of her work.

Because of our lack of knowledge of former methods and standards of excellence, as well as the various processes now employed by manufacturers, we are no longer capable of judging whether an article of food is pure or adulterated.

This very ignorance on the part of consumers places them at the mercy of the manufacturers and retailers, who pursue their vocations for profit, and are guided solely by business considerations.

Under the strong competition which now exists, the problem that especially concerns the manufacturers is to produce an article acceptable to the public at as little cost as possible, and to the solution of this problem they devote their energies.

The greater the demand for the products of their factories, and the cheaper the cost of production, the greater are their profits.

Whether the article is pure or whether it is what the name implies is oftentimes a matter of little or no consequence, provided it is salable and acceptable to purchasers. Consequently oleomargarine is found in the market as butter, a mixture of cottonseed oil, and tallow as lard; glucose syrup is made to take the place of honey; cottonseed oil is called olive oil; and milk thickened with glue or some vegetable gum passes for cream. Similar adulterations or substitutions might be named in a large variety of food products.

All gradations of mixing, adulterating and beautifying are practiced by manufacturers until, in many cases, the finished article bears no resemblance to the old-fashioned home product

of days gone by. To make an article salable and to produce it at the least possible cost are the key-notes to success.

The above statement must not, however, be taken as universally true. Most reputable manufacturers cater to the best class of trade, and put upon the market articles of a high standard of purity and excellence, but these same manufacturers, under assumed names, send out from their factories inferior articles of varying degrees of impurity to meet the varying demands of competition that exists in all classes of trade.

As a result of these changes which I have thus far attempted to describe, there has arisen an absolute need for a complete supervision of the public food supplies. A supervision which shall place some limit upon the substitution of cheaper and inferior methods and dangerous materials in place of the standard formerly used in our homes.

Hoping that enough has been said to lead us to see the necessity of some supervision, we will next briefly examine what legislation has been enacted for public protection.

As far back as 1860, the Legislature of this State enacted a law providing a penalty for the sale of unwholesome meat or bread, and also a law prohibiting the adulteration of liquors with substances injurious to health. Again, in 1878, a law was enacted making it a misdemeanor, punishable by a fine of twenty dollars for knowingly selling or offering for sale adulterated milk.

No adequate provision was made for the enforcement of these laws, and consequently they were never put in operation. The word "knowingly" in the milk law of 1878 rendered it of no practical value, as it is next to impossible in cases of adulteration to prove guilty knowledge.

It might be supposed that the demand for the establishment and enforcement of laws prohibiting the sale of adulterated food products would have come from the consumers, since it was for the benefit of the consuming public that these laws were enacted, but such was not the case. The demand for food legislation had, in this State at least, a totally different origin, namely, from the food producers, or in other words, the farmers.

Between the years 1880 and 1885, the markets of this State were flooded with oleomargarine, masquerading under the

name of butter. To such an extent was the imitation article sold for the genuine that the butter markets of this State were practically ruined, and the butter-makers and dairymen were almost driven out of business by the unfair competition to which they were subjected. In their distress they appealed to the Legislature for assistance, and as a result of this appeal the oleomargarine law of 1885 was established.

This law was exceedingly severe inasmuch as it forbade the manufacture or sale of any article in imitation of butter within the limits of the State of Pennsylvania. As a result of this law the few oleomargarine factories in this State were removed, but the sale of oleo. under the name of butter still continued to an extent almost as great as before. As there were no provisions made by the State for the proper enforcement of this law, the Farmers' and Dairymen's Protective Association, of Philadelphia, was organized to undertake the enforcement of the law in the eastern part of our State.

The following incident illustrates the extent to which oleomargarine was made to take the place of butter: In the year 1885, a gentleman bought thirteen pounds of print butter, one pound from each of thirteen different stores in the borough of West Chester. On analysis eleven of the thirteen samples proved to be oleomargarine.

The borough of West Chester is surrounded on all sides by a country population whose chief business is the production of milk and butter. In invading Chester County the oleo. people were pushing their business into the very center of a rich dairy district, and were robbing the farmers even of their own home markets.

From 1885 to 1893 this fight between the farmers and butter-makers on the one side and the oleo. men on the other continued. The struggle, however, acted only as a slight impediment to the business of the oleomargarine dealers. The attacks made by the butter-makers were sporadic in character, lacking in persistence and reaching only a few sections of the State. Moreover, the prosecutions when once begun were in many cases easily settled.

As to the result of this struggle between the butter interests and the oleo. interests the consuming public were apparently very indifferent. In fact, what little public sympathy was mani-

fested, appeared to be with the oleo. people rather than with the butter-makers. Public sentiment so far as it showed itself seemed to condemn the law of 1885 as unjust.

In the year 1893 an Act was passed enlarging the powers of the State Board of Agriculture and authorizing that body to appoint an agent, to be known as the Dairy and Food Commissioner, who should be charged with the enforcement of all laws then existing or thereafter to be enacted relating to the adulteration or imitation of dairy and food products.

In the year 1895 an Act was passed establishing a Department of Agriculture to be organized, and administered by an official, known as the Secretary of Agriculture, who was to be appointed by the Governor with the consent of the Senate. This deprived the State Board of Agriculture of the administration of all laws designed to prevent the adulteration of foods and transferred the office of Dairy and Food Commissioner, with all its duties to the Department of Agriculture.

The same year the Legislature enacted a general and comprehensive law forbidding the adulteration of foods, and gave the Dairy and Food Commissioner power to appoint such agents as were necessary to secure its enforcement, and also made an appropriation to meet the expenses of this department.

The enactment of this law of 1895 and enlarging the powers of the Dairy and Food Commissioner was the true beginning of the war against the sale of adulterated foods in Pennsylvania. By far the greater part of the prosecutions have been brought under this Act of 1895.

In order that we may have some idea of the character of this law I will read the first three sections:

ADULTERATION OF FOOD GENERALLY, INCLUDING ALL ARTICLES OF FOOD OR DRINK. (SEE ALSO LIQUOR, PAGE 60.)

*1. That no person shall, within this State, manufacture for sale, offer for sale or sell any article of food which is adulterated within the meaning of this Act.

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*27 June, 1895, §1. P. L. 317. Manufacture or sale of adulterated food prohibited.

**2. The term "food," as used herein, shall include all articles used for food or drink by man, whether simple, mixed or compound.

***3. An article shall be deemed to be adulterated within the meaning of this Act:

(a). In the case of food: (1). If any substance or substances have been mixed with it so as to lower or depreciate or injuriously affect its quality, strength or purity. (2). If any inferior or cheaper substance or substances have been substituted wholly or in part for it. (3.) If any valuable or necessary constituent or ingredient has been wholly or in part abstracted from it. (4). If it is an imitation of or is sold under the name of another article. (5). If it consists wholly or in part of a diseased, decomposed, putrid, infected, tainted or rotten animal or vegetable substance or article, whether manufactured or not, or in the case of milk if it is produced of a diseased animal. (6). If it is colored, coated, polished or powdered, whereby damage or inferiority is concealed, or if by any means it is made to appear better or of greater value than it really is. (7). If it contains any added substance or ingredient which is poisonous or injurious to health: Provided, That the provisions of this Act shall not apply to mixtures or compounds recognized as ordinary articles or ingredients of food, if each and every package sold or offered for sale be distinctly labeled as mixtures or compounds, and are not injurious to health.

The evident purpose of this law is the protection of the public from imposition and fraud and injury to health. It appears to have been the intention of our Legislature in passing the Act to protect the members of this Commonwealth from danger to life and health as well as from fraud in the purchase of food. This was the first Act to be passed solely for the safety and well being of the consumer. Ten years of experience has proved the wisdom of the Legislature that passed it.

I am sorry, however, to say that the people did not at first appreciate this law, probably because the need of it was not properly realized. Public feeling toward this and other food laws, has, however, undergone a very decided change. Where

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**Ibid. §2. Definition of term "food."

***Ibid. §3. What shall be deemed "adulterated food."

there was at one time a feeling of disapprobation, now there seems to be entire approval. This change I have had an opportunity to observe in magistrates' courts, in grand jury rooms, and in the different attitudes now taken by judges in giving their charges to juries. The vigorous enforcement of the food laws under the present administration has had much to do with changing public sentiment by showing the extent to which food adulteration is carried and the consequent necessity for protection.

Upon whom does the responsibility for adulteration rest? Upon the retailer or upon the manufacturer? Judging from my past experience, which covers a period of about twenty years, I am inclined to the opinion that the two parties are about equally guilty. There has been a strong tendency on the part of the public to hold the manufacturer almost solely accountable for the adulteration of food products. This feeling I am sure is, in part at least, a mistake.

It must be acknowledged that there is a large class of food substances put upon the market for the character of which the manufacturer is primarily responsible. In this list are included spices, cocoas, chocolate, strained honey, maple syrup, canned fruits and vegetables, and in fact nearly all goods put up in packages bearing the name of the manufacturer. If articles of this character are found to be adulterated, it is almost, if not quite imperative upon the manufacturer to protect the retailer from financial loss, for the manufacturer who fails to protect the retailer is sure to lose not only the trade of that one retailer, but also his trade in the town where that retailer is located.

As a matter of fact the manufacturer does, to a surprising extent, support the retailer in case of trouble caused by the sale of goods belonging in the list I have just named. There is another class of articles in the handling and sale of which the responsibility for fraud or deception rests largely upon the retailer. If a retailer is selling oleomargarine for butter, or a mixture of cottonseed oil and beef fat for lard, he usually knows what he is doing and is directly responsible for his acts. The retailer is also responsible for the sale of adulterated articles when he purchases his supplies from irresponsible parties and at prices much below their market value.

Some years ago an agent of the Department collected an unusually large number of very badly adulterated spices in a town in Eastern Pennsylvania. Analysis showed that the samples purchased from different grocers were of the same character and consequently had probably all come from one source. On making further investigation the agent found several tons of these ground spices stored away over a livery stable. Analysis of a sample taken from this stock showed that he had found the source from which the grocers had obtained their supplies. It was also found that the grocer had paid for these goods less than one-half the price necessary to buy pure spices, even of inferior quality.

While this is an unusual occurrence it is not entirely unique. Similar events have been observed in sufficient numbers to lead one to think that the manufacturers oftentimes find very enthusiastic allies among the retailers.

Many retailers are more than ready to cater to the public ignorance, or in other words, to deceive the public. They supply to their customers the cheapest articles they can buy, regardless of their character, so long as they are salable.

It is far easier to sell a given article of food at a low price than at a high price, even though it may be at a great sacrifice of quality. In certain markets a mixture of glucose and starch paste, colored and flavored with a little apple jelly, will find a ready sale under the name of currant jelly at a price which will furnish a good profit, while the genuine article could not be sold at a price that would pay for the handling.

Many retailers recognize this desire on the part of the consumers to buy cheaply, and wishing to take advantage of this fact to increase their trade demand the cheapest possible goods from their manufacturer, and they make this demand so imperative that even the most honest and reputable of these manufacturers are forced to yield, to some extent, at least.

Because there is a demand on the part of the public for cheap provisions, and because this demand is not attended with a proper discrimination as to quality the unscrupulous retailer seeks to enlarge his patronage by supplying low-grade or adulterated goods at low prices, thus underselling his more honest competitor.

In this way a retailer may acquire a patronage which he does

not fairly deserve, and which he would not obtain were his customers more capable of judging the quality of his goods. In reality these apparently low prices are furnishing large profits, and the honest dealer is placed at a decided disadvantage.

In just such cases as this the value of the Dairy and Food Department is most apparent. Not only the consumer, but the honest dealer as well, needs all the protection it can furnish.

I have no fault to find with the retailer who seeks to supply goods at low figures, nor with the consumer who wishes to practice economy, but too often this low figure is a trap to deceive the innocent and economical consumer and thus crime is committed. While the demand for cheap goods may serve as an excuse for adulteration, it is not by any means the real reason for it. Business interests prompt both the retailer and the manufacturer, and the desire on the part of each to make the profits as large as possible is the chief, and perhaps the sole cause for food adulteration.

Whenever a grocer buys supplies from irresponsible parties, or at a figure decidedly below the true market value of such supplies, he should assume the responsibility for the character of the goods he is offering to the public. This, I believe, is the view now taken by the Department on the question.

In closing this part of my address I feel that it is only fair to say that the present administration has with untiring energy waged a vigorous campaign against all varieties of food adulteration.

So far as I have been able to observe, this warfare has been waged without favoritism or malice, and regardless of political, financial, social or business influences.

Retailers, manufacturers, wholesalers, prominent as well as humble, have been summoned to answer charges of selling adulterated food, and in all cases, so far as I have seen, there has been manifest on the part of the attorneys representing the Department a willingness to consider where the responsibility rests.

From the work done in my laboratory I have tabulated a list of frequently adulterated articles. This list includes all the samples of the kind that were analyzed during the past seven or eight years. It does not at all represent the conditions of our

markets for the reason that the samples were taken by agents who were hunting for adulterated articles and consequently collected only samples concerning the composition of which there was uncertainty.

On the other hand this table does not show as high a percent-

Sample	Total	Pure	Adulterated	Sample	Total	Pure	Adulterated
Butter	1303	626	677	Fruit Syrups .	93	18	75
Beer	102	75	27	Honey	83	39	43
Blackberry Brandy	514	143	371	Hamburg Steaks	205	75	130
Chocolate . . .	251	184	67	Lard	234	119	115
Cocoa	151	128	23	Molasses . . .	62	18	44
Cream of Tartar	127	65	62	Maple Syrup .	106	37	69
Coffee	109	68	41	Olive Oil . . .	96	46	50
Cheese	152	143	91	Spices	595	320	275
Condensed Milk	73	68	5	Wines	256	162	94

age of adulteration in the samples actually analyzed as it should. Only those samples that were so clearly and distinctly adulterated as to make satisfactory cases for prosecution were placed in the column marked adulterated. For this reason many samples that were more or less adulterated have found their way into the column head pure.

Immediately after the passage of the food law of 1895, Thomas J. Edge, then Secretary of Agriculture, caused an investigation to be made in regard to the condition of the food supply then found upon the markets. The analyses made by me at that time showed a very high percentage of adulteration in the following articles: Butter, lard, honey, chocolate, cocoa, ground coffee, cream of tartar, spices, olive oil, canned fruits, jellies, jams, flavoring extracts and cider vinegar. In many of the above-named articles the adulteration was as high as from 50 to 75 per cent. of the total number examined. To illustrate, out of eleven samples of cider vinegar purchased in West Chester nine were not produced from apple juice.

At the present time I believe there is less than one-tenth as much adulteration as existed at that time. I am very much

pleased to be able to say that at no time has there been a very large percentage of adulteration of milk. There was a time, however, when it seemed that the use of milk preservatives was about to become quite general. The enforcement of the law relating to this subject nevertheless averted this impending evil. During the past summer about 3 or 4 per cent. of the samples of milk and cream examined were found to contain preservatives.

ANOTHER TURBINE ATLANTIC LINER.

Contemporaneously with the completion of the maiden voyage of the first turbine Atlantic liner, the "Victorian," the sister ship "Virginian" was running her speed trials on the Firth of Clyde, when she developed the very creditable speed of 19.8 knots an hour. Compared with the daily records of the fastest Atlantic liners, this performance is not, of course, remarkable; but when we bear in mind that these two ships were designed originally for a sea speed of about 17 knots an hour, it will be seen that the accomplishment of nearly 20 knots on trial is one more tribute to the capacity of the marine turbine to exceed, when pushed to the limit, by a considerable margin the results for which it is designed. The "Victorian" showed a trial speed of a fraction over 19 knots an hour. The first ocean voyage of the "Victorian," which consumed 7 days 22 hours and 50 minutes, was made under extremely unfavorable circumstances, as she started in a gale of wind, encountered bad weather on the way across, and was obliged to go considerably to the south of her natural course, as far south indeed as the latitude of New York, in order to avoid the icebergs, thereby lengthening her voyage by more than 300 nautical miles. Moreover, it was stated by the captain that the boilers gave considerable trouble by priming. The maximum speed reached during the voyage was 16½ knots. The "Virginian" completed her first voyage under favorable wather conditons in 6 days, 22 hours and 45 minutes. This is the fastest record. On the important question of vibration, the officers and passengers appear to be unanimous in stating that it was practically eliminated in these ships. This, of course, does not prove that there will be a similar absence of engine vibration when a liner with turbine engines is being driven at the speeds of 23 to 23½ knots, at which the fastest of the German ships have been driven by their reciprocating engines. But it is fair to presume that even at such high speeds the vibration will be confined to that which comes from the propeller.—*Scientific American.*

COMPOSITE BRICKS OF UNUSUAL STRENGTH.

A test made at Purdue University, Lafayette, Ind., of composite bricks made at Indianapolis, of sand, cement and lime, showed a crushing strength of more than 15,000 pounds, as against 1,500 pounds for an average clay brick and 3,500 pounds for an average faced brick. In transverse strength the composite brick showed a resistance of over 2,500 pounds.

COAL TESTS.

An opportunity has been offered the coal producers of the country to co-operate with the United States Geological Survey in its work of testing the coals and lignites of the United States. This work was begun at the World's Fair Grounds, St. Louis, during the Exposition and will be continued along the lines laid down at that time. The Survey is desirous of securing from operators and others interested in the problems of fuel consumption an expression of opinion as to whether they desire to co-operate in this work. Offers of coal for testing purposes should be addressed to the Director of the United States Geological Survey, Washington, D. C.

It is not possible to promise at the present time that all offers of coal will be accepted, but the plan is to make the investigation as complete as practicable, distributing the work as impartially as possible over the entire country. The distribution of the work will depend largely upon the replies received to the circular which the Survey is now sending out to coal operators and upon the present and possible future development of the coal and lignite deposits of the several States.

The tests will be made for the purpose of determining the fuel values of the different coals and lignites and the most economical methods for their utilization. Arrangements have been made with the manufacturers of the equipment used during the Expositon to have practictlly all of this testing machinery left at the disposal of the Government.

In offering coal for testing purposes, operators are requested to note the following conditions with which it is necessary to comply:

1. The coal must be furnished to the Testing Plant free of cost to the Government.

2. The coal must be loaded under the supervision of one of the inspectors employed for that purpose, who shall be at the same time allowed to visit the working places in the mine to procure samples for analysis.

3. When it is possible to do so, the coal should be loaded in box cars and shipped under seal. Lignites must always be shipped in this way.

4. Where the market requires screened coal, this grade will be accepted for test. The selection of coal is always to be under the direct control of the representative of the testing plant.

5. Where one of the problems involved is the better utilization of slack coal, a carload of slack may be accepted for testing purposes.

6. As soon as possible after the tests are completed a brief statement of the results will be furnished to parties supplying the coal, for their information, but this must not be made public until the results are published by the Geological Survey.

7. Everyone interested in any particular test or in the general operation of the plant is invited to be present at any time, but the official record of the test will not be given out except as indicated in the preceding paragraph.

CHEMICAL SECTION.

(Stated Meeting, held Thursday, January 19th, 1905.)

The Chemistry of Electroplating.

By Wilder D. Bancroft.

[The author presents in this paper the most recent facts relating to the electrolytic precipitation of the metals.—The Editor.]

It is my object to-night to show that many of the peculiarities attending the electrolytic precipitation of metals become clear when we consider the chemistry of the reaction and follow out chemical analogies. For the purposes of discussion we will define a good deposit as one in which the metal comes down in a pure, fairly adherent, reguline form. Except possibly in the case of treeing, a bad deposit apparently is due always to the precipitation of a salt of the metal. This is usually an oxide or hydroxide, but may be a simple cyanide in cyanide solutions. It is often stated that the precipitation of hydrogen makes a deposit bad. There seems to be a confusion here between cause and effect. In electrolytic analysis hydrogen is evolved and yet the deposit remains good. Further, the so-called critical density varies enormously with the size, shape and distance apart of the electrodes, and also with the size and shape of the containing vessel. The most important factor is the rate of stirring. If a solution gives a good deposit at some current density, it seems probable that a good deposit can be obtained at any higher current density provided the stirring is sufficiently rapid to prevent impoverishment of the film at the surface of the cathode. When a deposit becomes sandy or changes to a black powder with increasing current density, the polarization shows that there has always been

the formation of a dilute solution at the cathode. In most cases this leads to the precipitation of an oxide or basic salt, with the usual disastrous results.

If a bad deposit is always due to the precipitation of a salt, the addition of anything that will dissolve the salt readily under the conditions of the experiment will prevent its deposition and should therefore improve the quality of the deposit. I have made a list of the more important additions recommended in the refining, analysis or plating of zinc, nickel, lead, tin, copper and silver. These are given in Table 1.

TABLE I.

Zinc.	*Tin.*
Sulphuric acid	Sulphuric acid
Potash	Potash
Ammonium chloride	Sodium pyrophosphate
Ammonium sulphate	Potassium carbonate
Aluminum sulphate	Acid potassium tartrate
Potassium cyanide	Potassium cyanide
Acid potassium oxalate	
Nickel.	*Copper.*
Sulphuric acid	Sulphuric acid
Ammonia	Ammonia
Ammonium salts	Alkaline tartrate
Potassium cyanide	Ammonium oxalate
Sodium bicarbonate	Potassium cyanide
Sodium bisulphite	Sodium bisulphite
Lead.	*Silver.*
Acetic acid	Nitric acid
Potash	Ammonia
Fluosilicic acid	Potassium cyanide
Sodium nitrate	Potassium iodide

All the substances under zinc dissolve zinc hydroxide. The first four under nickel dissolve nickel hydroxide; the sodium bicarbonate probably serves to keep the acidity constant; while the sodium bisulphite occurs only in solutions containing free ammonia. All the substances under lead dissolve lead hydroxide. Stannous and stannic acids are soluble in sulphuric acid, in potash, and in a so-called sodium pyro-phosphate solution; potassium carbonate is added only to neutralize an excess of free acid in stannous chloride solutions; while the cyanide and tratrate seem to be of very little value, unless perhaps at the anode. Under copper, everything dissolves the hydroxide except sodium bisulphite and this is added to cyanide solutions to prevent loss of cyanogen when the copper changes

from the cupric to the cuprous form. All four substances under silver dissolve freshly-precipitated oxide; in addition ammonia dissolves silver chloride, while silver cyanide and silver iodide are soluble in potassium cyanide and potassium iodode respectively.

It is thus clear that there is a simple rational basis for many of the solutions in actual use. It must be kept in mind, however, that the rate of solution is more important than the actual solubility. Thus it is not easy to get a good deposit from an alkaline zincate solution at 20°, whereas it is a comparatively simple thing to do this at 40°, because the caustic soda reacts with zinc oxide or hydroxide much more rapidly at this temperature. It does not follow from this that a higher temperature would necessarily be even better. At 90° the action of caustic soda on metallic zinc becomes an important factor. With copper sulphate solutions, rise of temperature means increased formation of cuprous sulphate, and this must be taken into account. In each of these cases a study of the chemical reactions shows the cause of the difficulty.

We now come to the more interesting side of the question: to the factors affecting the size of the crystals in electrolytically-deposited metals. It will be well to run over briefly what our chemical analogies would lead us to expect, and then we can consider how closely the predictions are fulfilled.

Rapid crystallization of a salt from solution gives us small crystals, while slow crystallization leads to larger crystals. We should, herefore, expect the crystalline structure of the electrolytically-deposited metals to be finer the more rapid the precipitation, in other words, the higher the current density. At high temperatures chemical precipitates are more crystalline than at lower temperatures. Two striking instances of this are barium sulphate and alumina. If we increase the difficulty of precipitation we should expect that the crystals would have more difficulty in reaching a large size. We therefore conclude that we shall get a more nearly amorphous deposit from a dilute solution than from a concentrated one, provided all conditions remain the same. We can generalize this and say that the greater the potential difference between metal and solution the finer will be the elctrolytic deposit. At one time I thought that this could be carried still farther, and that we could say

that neutral solutions would give coarser deposits than acid ones; that oxidizing agents would cause fine deposits and reducing agents coarser ones. Further experiments have shown that this is not generally true and that the effect varies from metal to metal and sometimes from concentration to concentration.

We know that the addition of a colloid to a solution increases the probability of a precipitate coming down colloidal, and that chemically precipitated metals are rarely pure. From this we conclude that addition of a colloid to a solution will make the electrolytic deposit more finely crystalline and that the carrying down of substance with the metal will tend to make an amorphous deposit, always provided that the substances carried down do not spoil the deposit entirely.

We can now consider the experimental results. With zinc sulphate, sodium zincate, copper sulphate, silver nitrate and stannous chloride solutions, the crystals become smaller as the current increases. The silver nitrate solutions were especially interesting. At St. Louis, last summer, the point was raised that it was impossible to obtain a fine-grained deposit of silver from silver nitrate solutions, no matter how high the current density was raised. In our first experiments with silver nitrate it was not possible to detect any effect due to current density. This was somewhat discouraging. Since a silver salt is formed at the anode which increases the weight of the cathode deposit, it was thought that this same salt might affect the crystalline structure of the metal. The experiment was repeated using a porous cup to separate the anode and cathode solutions. We then obtained smaller crystals with higher current density. With twenty amp. q. d. m. the deposit could be burnished.

With an acidified copper sulphate or zinc sulphate solution, the deposit became coarser as the temperature was raised from 20° to 40° and to 70°. With a zinc sulphate solution which was only faintly acid, the deposit was coarser at 70° than at 40° but was coarser at 20° than at the other two temperatures. I suspect that at 20° the slight acidity had no appreciable effect on the deposit, while it became an important factor at 40°.

The effect of concentration is that required by the theory. With zinc sulphate, sodium zincate, copper sulphate, and silver nitrate solutions, smaller crystals were obtained from the more

dilute solutions than from the more concentrated ones. The deposit from the zinc sulphate solutions was coarser that that from the sodium zincate solutions, these last being very smooth. It is a recognized fact that silver and copper precipitate well from potassium cyanide solutions. Silver nitrate in pyridine gives a finer deposit than in aqueous solutions. From sodium stannate solution much smaller crystals were obtained than from a stannous chloride solution.

The addition of sulphuric acid to a neutral solution of copper sulphate makes the deposit much finer. We have not yet noticed a corresponding effect with any other metal and are therefore forced to believe that this is characteristic of copper, in which case it is probably connected with the presence of cuprous sulphate in the neutral solution. This point cannot be considered as settled definitely. The addition of formaldehyde made the metal deposited from zinc sulphate solution finer, while it coarsened that from the zincate solutions. Addition of formaldehyde improved the deposit from copper sulphate solutions, while the addition of a good deal of nitric acid made the copper crystals finer than when deposited from a neutral solution, but coarser than when deposited from a solution acidified slightly with sulphuric acid. An excess of nitric acid makes the deposit from a silver nitrate solution coarser at high current densities and finer at lower densities.

Coming next to the question of colloids we know that the addition of glue to lead fluosilicate solutions improves the quality of the deposit enormously. In the laboratory we have tried the effect of ten grains of glue per liter. With zinc, copper and tin, the crystalline structure was much smaller than without the glue. With a silver nitrate solution we obtain a violet deposit which is apparently amorphous silver. Though we have not yet had time to test this thoroughly, it seems probable that we have here an explanation of "bright" deposits. A bright deposit is one in which the crystals are so small that the deposit is practically amorphous. By using less glue in our silver nitrate solution we could probably get a fairly bright deposit. We have not yet analyzed the silver deposit from a solution containing glue, but it is probably not pure. Carbon bisulphide is the substance most often added to silver cyanide solution to cause a bright deposit, and this bright silver is said to contain

sulphur. When too much carbon bisulphide is present, the deposit is said to become black. I think that it has usually been assumed that this black color was due to silver sulphide; but it now seems possible that a violet colodial silver is precipitated. Jordis states that bright deposits of many of the metals can be obtained from lactic acid solutions. Since the metal deposited from a solution of an organic acid may easily contain carbon, it becomes quite possible that there is an intimate connection between the two facts.

It has been noticed by many observers that a bright or burnished deposit can be obtained when one rotates the cathode and uses high current densities. Those who made these experiments were interested primarily in increasing the current density and they varied the speed of rotation and the current density simultaneously. Consequently, one did not know whether the burnished effect was solely the result of the current density or not. To test this question Mr. Snowdon made some experiments with a silver cyanide solution and a rotating cathode. The current density and speed of rotation were so adjusted that a bright deposit was obtained. Then the speed of rotation was kept constant while the current density was increased. Since an increase of current density would decrease the size of the crystals, the deposit should have become even brighter if the current density were the only factor. As a matter of fact the deposit was distinctly frosted. The only explanation that I have been able to find is that the moment of precipitation there is a polishing effect due to surface friction. If more metal is deposited in the unit of time than can be polished, the metal is frosted. While this explanation may not seem satisfactory to everyone, it does account for the facts, and this is certainly a point in its favor.

It has been noticed that the presence of salts of cadmium, iron, lead and copper interfere with the satisfactory precipitation of zinc. The reason for this is very simple. These metals precipitate before zinc and set up a local circuit which oxidizes the zinc and causes the deposit to become faulty. This local circuit may make trouble in other cases. When we have to plate a noble metal on a less noble one, we usually make use of a striking-bath in which the difference of potential between the two metals is not very great. This keeps down any non-electro-

lytic precipitation to a minimum. When we are depositing a less noble metal on a more noble one, we never bother ourselves about the formation of a couple and we may be thereby led into serious error. Zinc will precipitate nicely on a zinc cathode when it will not deposit well on a copper cathode owing to the evolution of hydrogen. The difficulty about precipitating zinc with a low current density is due chiefly to local action at the cathode. It seems probable that this also accounts for its being so much more difficult to precipitate lithium on a platinum electrode than on an iron one.

Another point of importance to the plater is the adhesion of the deposit. While it has been suggested that an adherent deposit can be obtained only when the two metals can combine to form compounds or solid solutions, this contention does not seem to be in accord with the facts. The surface between two metals is a thin weld and it must show the same strength, no matter how it has been made. In other words, the adhesion of an ideally-made electrolytic deposit will approach that of a casting having the same size of crystals. Presence of grease, of air-bubbles, or of occluded mother-liquor will impair the contact and weaken the joint. If the metal be deposited in a state of strain, the break will come at the weakest point. These are matters of general knowledge in making welds or castings, and they are just as much first principles in electrolytic work. No one seems to have been struck by the absurdity of the statement, to be found in most books on plating, that nickel cannot be plated on nickel, because it will not adhere. If this were true it would not be possible to deposit more than an infinitesimally thin film of nickel electrolytically. While it requires a higher voltage to deposit nickel than copper, nickel does not precipitate copper to any appreciable extent when immersed in a copper sulphate solution. The nickel becomes passive and is probably covered with a thin film of oxide. What is meant is that an "active" nickel containing hydrogen will not adhere to a "passive" nickel. There is nothing surprising or mysterious about this. By making a nickel electrode the cathode in an acid solution for a few minutes before putting it in the nickel bath, Mr. Snowdon has been able to plate nickel on nickel getting a beautifully adherent deposit.

The theory which I have outlined for you to-night has been

able to account for the phenomena due to added salts, current density, temperature, concentration, solvent, colloids, other metals, and cathodes. It has not accounted for the effect of acids, oxidizing agents and reducing agents; but this seems to be due to our ignorance of the chemistry of these solutions.

THE PRODUCTION OF TALC AND SOAPSTONE.

The total production of talc and soapstone of all varieties during 1904 was 91,189 short tons, valued at $940,731. As compared with 86,901 short tons, valued at $840,060, in 1903, this is an increase of 4,288 tons in quantity and of $100,671 in value, due partly to a general increase in the production of talc from all States, but principally to the large increase in the production of fibrous talc in New York. In 1903 there had been a large decrease in the production of fibrous talc in New York as compared with the production of 1902, which was due to long-protracted strikes at some of the paper mills.

Of the 1904 production, 27,184 short tons, valued at $433,331, were obtained from all the States exclusive of New York. This value includes that of the manufactured product made from the talc, as only a small quantity of the product is sold in the crude state. The production came from nine States, and these, together with the number of producers in each, were as follows: California, 1; Georgia, 2; Massachusetts, 1; New Jersey, 1; North Carolina, 5; Pennsylvania, 2; Vermont, 3; Virginia, 2, and Washington, 1, a total of 18 producers.

The production of fibrous talc from New York amounts to nearly double that obtained from all the other States, and almost all of it is used in the manufacture of paper. In 1904 the New York output amounted to 64,005 short tons, valued at $507,400, as compared with 60,230 short tons, valued at $421,600 in 1903. The average price for a ton of talc in 1904 was $7.92, as compared with $7 in 1903, and with $8.65 in 1902, an increase of 92 cents a ton over 1903, and a decrease of 73 cents a ton as compared with 1902.

The importation of talc into the United States has been very irregular and never amounted to much. The quantity and value of the talc imported in 1904 was greater than in any previous year. It amounted to 3,268 short tons, valued at $36,370.

The above facts are taken from the report of Dr. Joseph Hyde Pratt, of the United States Geological Survey. Dr. Pratt's report is now out as an extract from the Survey's forthcoming volume, "Mineral Resources of the United States, 1904."

Mining and Metallurgical Section.

(Stated Meeting held Thursday, March 4th, 1905.)

New Methods in the Metallurgical Treatment of Copper Ores.

By N. S. Keith.

[A method is here described for the utilization of low-grade copper ores.—The Editor.]

In many sections of the United States there are vast deposits of sandstone, carboniferous, triassic, and earlier, which contain copper, either in the metallic state, or mineralized as sulphides and carbonates. The chief sulphide is Cu_2S, variously called chalcocite, copper glance, or cuprous sulphide. Sometimes chalcopyrite occurs, more or less mixed or combined with iron pyrites; but comparatively infrequently. In the eastern section of the country these cupriferous rocks are noticeably occurrent in the Appalachian ranges, from Maine and Vermont to the Carolinas.

In the sandstone regions, disconnected from the main range, such deposits have been found, and have been somewhat exploited from the earliest years of the history of the country.

Beyond Maine, along the coast of New Brunswick, there is a considerable tract of cupriferous, carboniferous sandstone at Dorchester. In Connecticut, not far from New Haven, are copper-bearing sandstones. In New Jersey, at Arlington, eight miles west of New York City, are such sandstones of the triassic formation, with intrusive trap dykes and sheets, from which trap the copper impregnations were probably derived.

On the banks of the Delaware River, in Warren County, New Jersey, a few miles above the Delaware Water Gap, are cupriferous rocks, classed as Medina and Oneida sandstones, of an older period than the triassic, and not associated with trap rocks, or other evidences of volcanic disturbances. There are other places in New Jersey where sandstone deposits have had attention given them.

In Adams County, Penna., not far from Gettysburg, there are sandstones which contain not only chalcocite and carbonates, but metallic copper. In this case, as in all of the others, the copper carbonates (malachite and azurite) occur at and near the surface, and are the result of the action of the atmosphere and carbonated waters on the chalcocite and metallic copper.

All of these sandstones are essentially silicious, being built up from quartz grains cemented together by silica from thermal waters containing silica in solution. This silica solution may have been, and probably was, the result of the solvent action of the thermal waters on the sand itself while lying on a horizontal plane, from which position the sandstones have been moved to planes having various dips from their original ones.

The sandstones frequently contain a small percentage of calcium carbonate, or calcium in some other combination, such as the sulphate.

In Virginia, near Virgilina, on the boundary line of North Carolina, there is a mineralized belt of country extending 25 miles north and south in the two States. The country rock is slate, in this slate there are quartz veins and porphyry dykes, parallel with each other, and conformable with the stratification of the slate.

These veins and dykes carry carbonates of copper and chalcocite, with bornite, and occasionally chalcopyrite. These rocks are silicious, as in the other cases.

Besides their contents of copper the rocks at the various points I have named carry gold and silver, in amounts varying from traces to some dollars in value per ton of rock. The copper constituent averages in the several cases at from one per cent. to three per cent. of the weight of the rock; that is, from 20 to 60 pounds per ton.

There are many other places at which like rocks are obtainable; but these serve to illustrate prevailing conditions, and to show the foundation for the methods of treatment which I am about to consider.

In all of these cases the smelting of the rocks to obtain their metals is possible in theory, and practicable under favorable conditions; but these favorable conditions are absent. The unfavorable conditions are:

(1). The absence of, or expense of, suitable fuel at the mines.

(2). The absence of, or the expense of, suitable fluxes, such as iron oxides, iron sulphides, or limestone, at the mines.

(3.) The cost of transporting the rock to the neighborhood of fuel and fluxes.

(4). The "low grade" of the rock. That is to say, the copper, gold and silver are not in quantities enough to yield values sufficient to pay either for bringing the fuel and fluxes to the mine, nor for taking the rock to the fuel and fluxes.

There are places where copper ores and rocks of no higher grade than these are worked at a profit. But they are where the ores are "self-fluxing." That is to say, where the ore itself is composed of materials which naturally react on each other in the furnace to produce slags which are liquid enough to permit the metals to come together, and where the necessary fuel is cheap enough; or, in cases where there are cheaply obtainable suitable ores to admix so as to make a fusible mixture. Then again, the rocks which have their copper in the metallic state can be worked after the methods pursued at the Lake Superior mines, where rock containing less than 15 pounds of copper per ton are mined and reduced at a profit.

But I am to consider the treatment of silicious rocks where the considerations are unfavorable for smelting.

Foremost among the methods which have been tried is that of "leaching." Leaching consists in submitting the cupriferous material to the action of solvents of the copper constituent, and then reducing the dissolved copper from the solution by means of a reducing agent. The rock must first be crushed and ground to a fineness, say that of fine sand, so that the solvent may have access to all of the copper mineral. About the only available solvent of the chalcocite and metallic copper is a solution of ferric sulphate or of ferric chloride. A solution of either of these salts of iron dissolves, though slowly, both chalcocite and metallic copper, by forming copper sulphate or copper chloride, and the ferric solutions are changed to ferrous solutions. These ferrous solutions are changed by exposure to air, by absorption of oxygen, to the ferric state; and are then again usable to dissolve more copper. The copper may then be deposited from its solutions by means of metallic iron, generally scrap, or by means of electricity.

This seems at first glance a simple process. But there are

serious complications, chief among which is the presence of lime, or calcium compounds, in the rocks, as is almost always the case.

The lime acts up to its limit in quantity to neutralize its combining equivalent of the sulphuric acid, or chlorine, constituent of the solvent, and that action is preferential above that on the copper. The only exception to this is when the lime is present as a sulphate, which is seldom. It is generally calcium carbonate.

The next leaching method is to grind the rock to a sand, as before, and then roast it, so as to oxidize its oxidizable constituents. The result then is, if the operation is carefully performed, the formation of oxide of copper in the sand, and of some calcium sulphate, and some calcium oxide, or lime. Then the roasted sand is leached with a dilute solution of either sulphuric or hydrochloric acid. But this has been found impracticable where acids are expensive, and where there is lime in quantity as low, even, as one-half of one per cent. of the rock.

If there be at hand some sulphide ores, as of iron, carrying some copper, say two per cent. of the latter, it may be ground and mixed with the ground sandstone or quartz and roasted as before. Then the lime will sulphated and will not thereafter combine with the acid to its loss in the subsequent leaching.

Having thus obtained the solution of copper, with questionable economy, the method of precipitating the copper therefrom by the use of iron scrap, or pig, is pursued in various localities. This method of precipitation of copper is very old and well known, and is only one of the steps constituting some of the modern methods pursued in obtaining that metal. But, to-day, that step is too costly in most localities. While, theoretically, 56 pounds of iron should precipitate 63.35 pounds of copper, in practice nearly three times that quantity of iron is used. This comes from excess of acid in the copper solution, a waste in itself, uniting with its equivalent of iron; from oxidation of iron; from the formation of ferrous salts; scale and rust and dirt on the iron as purchased, small pieces undissolved, etc. Then the precipitated copper is very impure. It contains on the average about 70 per cent. of copper. The other constituents of this "cement copper," so-called, is iron oxide, sand, and other extraneous matter, which must be removed by smelting.

A better method is this: Having obtained the solution of copper by some method, it is deposited by means of electricity. In brief, this is accomplished by immersing the electrodes of a source of electricity into the copper solution, and causing a graded current of electricity to flow from the anode through the solution to the cathode. In this way, if the strength of the electric current be properly proportioned to the amount of copper in the solution (the electrolyte) at all instants of the time of the operation there will be produced on the cathode a deposit of reguline copper of great purity, and in a commercial scale much cheaper than by iron as above outlined.

But the anode must be insoluble. In sulphate solutions lead stands the action in the bath much better than any other sufficiently cheap material. Carbon anodes do not endure in sulphate solutions, but are practicable in use in chloride solutions, in which lead anodes are quickly chloridized. But lead anodes must be, as far as possible, kept continually in action to prevent them from sulphating. The cathode is generally a thin sheet of copper at the start, prepared by the electrodeposition of copper on a cathode of lead, from which latter it is stripped when thick enough for use.

Under the just-described method it is necessary, in order to economically deposit the ultimate quantity of reguline copper within a required time, to begin the deposition by use of the current at its maximum density between the electrodes, permissible in the production of reguline metal on the cathode, and retrogressively decrease that density as the action goes on, and in proportion to the decrease of the metal in the solution, till, at the end the minimum density of current is in use, and the minimum amount of copper is left undeposited in the solution.

It is not necessary to deposit all of the copper, because the solution will be used again to dissolve more copper, the acid from the deposited copper being freed by the electrolytic action so that it may again combine to form a soluble salt of copper.

It is evident from the above that the source of electricity, a dynamo, is not acting during the time on the average above one-half of its capacity. It was started at its maximum and finished at its minimum.

To obviate this difficulty I have devised the following described apparatus and method: The deposition vats are placed

in series so that the liquid or solution is caused to flow from the first to the last in regular succession. They are also connected with the dynamos in electrical series, so that the electric current flows through all in equal strength in amperes.

As the solution has, in practice, a nearly uniform amount of copper per unit in it as it flows into the first vat of the series, that vat has in it a cathode surface which permits the deposition of about the maximum amount of reguline copper obtainable on that area of surface.

That area is limited by the amperes of current available. In other words, the density of current is such that reguline copper is deposited, but the density of current is less than that which causes the deposition of a brown, sandy deposit.

In the second vat is a larger cathode area. As the same amperes of current flow in this vat, the density of current is less, because the area of cathode is greater. The same amount of reguline copper is deposited as in the first vat, and in the same time, but over a larger area.

The same progressive increase in cathode area is made in each successive vat of the series. The same current flows through all, but its density is less and less through the several vats of the series, so that reguline copper is deposited to the same amount in each, until the depleted solution flows out of the last vat of the series, to be again used to dissolve copper from more rock or ore. In this way the electricity is used most economically.

But none of these leaching methods obtains the gold and silver which almost invariably accompanies the copper. To obtain these leaching by cyanide of potassium solutions might be performed after thoroughly washing the pulp which has been treated for copper. But this will often be found too expensive for the values obtainable.

I have devised and put into successful operation the following described method of treating the silicious copper-bearing rocks which we have been considering. It is based on these chemical and metallurgical facts:

Silica alone is infusible at temperatures at which copper, gold and silver are melted. In those rocks there is not enough iron or lime to act as fluxes for the silica, which last averages 90 per cent., or more, of the whole.

Oxide of iron, and *oxide of calcium*, separately, are likewise infusible.

Copper carbonates, azurite and malachite, when exposed to red heat, are decomposed; carbon oxide is freed as a gas, and cupric oxide remains. If the atmosphere in which this decomposition takes place be a reducing one, say carbon monoxide, then the copper is reduced to the metallic condition by passing of the oxygen of the cupric oxide to the carbon monoxide to produce carbon dioxide. If the temperature be high enough to melt copper that will be found in small metallic globules if the carbonates were diffused in the rock.

Chalcocite, or copper glance, $Cu_2 S$, when exposed to a like heat in an oxidizing atmosphere, as on the hearth of a roasting furnace, is decomposed; the sulphur partly distils off, and is partly oxidized to sulphurous acid, SO_2. The copper is first freed as a metal, and then rapidly oxidized to cupric oxide. If, then, the character of the flame and gases be changed to a reducing nature the copper oxide will be reduced and fused as stated above.

If *carbon*, such as coal, be ground or pulverized, and be projected into a flame in a furnace with free access of air, it immediately ignites and is oxidized to carbon monoxide and carbon dioxide. If the air be insufficient to furnish oxygen enough for the formation of dioxide only monoxide will be formed.

The air admitted with the powdered carbon may be sufficient to form at the first stage of the combustion only carbon dioxide, but as the action continues, the hot particles of carbon absorb half of the oxygen of the dioxide, reducing the latter to monoxide.

The atmosphere resulting from this operation consists of nitrogen, from the air, and carbon monoxide from the union of the oxygen of the air with the carbon. There are, also, small quantities of gaseous hydro-carbons, because of reactions due to the presence of water in the air and in the coal. This atmosphere of hot gases is ready to, and does, take oxygen from hot oxides, and thus reduce them to the metallic state.

The practical, working, furnace in which the several reactions above recited take place, consists of a vertical shaft about

twenty feet high, constructed of red brick with a fire-brick lining.

At the top of this shaft are many holes, or openings, through which the powdered rock, powdered coal and flames from producer gas, or like fuel, are introduced. The bottom of the interior of the shaft is inclined at an angle of about 45 degrees, and this incline is extended into a dust-collecting chamber. This chamber, in turn, connects with another vertical shaft, also with an inclined bottom, dipping toward the other incline. The interior of this shaft is filled with pieces of coke, or small stones. This latter shaft is called the "condensing chamber." Near its top is a sprinkler to distribute water over the coke or stones, after the manner of a gas washer or scrubber. The draft for this furnace is produced by an exhaust fan through a pipe from the top of the condensing chamber. The draft is downward in the first shaft and upwards in the condensing chamber.

The operation by which copper, gold and silver are extracted from the silicious rocks is described as follows:

The rock, as it comes from the mine, is dumped from the cars into a crusher, or a series of crushers, which reduces it to sizes suitable for the pulverizers, into which it is automatically fed, and in them reduced to powder. The fineness of this powder is determined by the diffusion of the copper mineral in the rock; and it should be so fine that the particles of rock and mineral are no longer coherent; but, of course, still mixed. The degree of comminution is measured by sieves, which may be as fine as sixty mesh, or finer, or coarser, according to the above requirement.

At some stage of this process of comminution finely pulverized coal, in weight about three per cent. of the rock, is intimately mixed with the powdered rock, and the mixture is deposited in a hopper above the furnace shaft.

The draft and gas flames having been started, the comminuted mixture of rock and carbon is continuously fed into the holes at the top of the shaft, passing int othe furnace with the flames and air. The particles of carbon and of copper mineral are immediately ignited and oxidized by the oxygen of the air in which the particles are suspended and diffused.

This oxidation is combustion, and produces an intense heat.

At first the carbon particles have their surfaces oxidized to produce carbon dioxide; but as the particles pass further down the shaft the oxygen of the air supply becomes exhausted, and then the carbon dioxide parts with half of its oxygen to the unburned incandescent carbon to form carbon monoxide, which last, in its turn, acts upon the oxides of copper and silver, taking their oxygen, thus reducing them to the metallic state.

As the heat is intense, these particles of metal are melted and assume globular shape.

The gold particles are likewise fused. The heat does not fuse the silica nor the lime. The result of this operation is a sand carrying in it minute globular particles of copper, gold and silver.

The dust and condensible gases are collected on the wetted surfaces of coke or stones in the condensing chamber and washed by the water to the bottom, where the water also meets the sand and carries it out of the furnace, in a constant stream upon concentrators, which separate the sand from the metal particles.

The metallic concentrates are then dried, melted and cast into merchantable shapes; such as copper anodes, when there is enough gold and silver to pay for the expense of electrolytic refining and separation of the associated metals.

The process is a continuous one and automatic from start to finish. It is cheap; and under the economic conditions of the localities we have considered the cost does not exceed one dollar per ton on a scale of treatment of one hundred to two hundred tons per day of 24 hours.

The gas drawn from the furnace by the exhaust fan is a combustible one, consisting mainly of carbon monoxide and nitrogen, and may be used for heating purposes. The sulphur dioxide and carbon bisulphide, if any of the latter, are condensed in the chamber and pass off in the water.

The limits of this paper do not admit of entering into specific details of construction and operation.

The process is applicable in many case where older methods are not practicable.

PRODUCTION OF MICA IN 1904.

Although mica has been found in commercial sizes in about one-third of the States and Territories, it has been mined during the past year in North Carolina, New Hampshire, Colorado, New Mexico, California, Georgia, South Dakota and Utah, which are named in the order of their importance as mica producers

The total quantity of sheet or plate mica produced in this country during 1904, as computed by Dr. Joseph Hdye Pratt of the United States Geological Survey, was 668,358 pounds, valued at $109,462, an increase of 48,758 pounds in quantity but a decrease of $8,626 in value, as compared with a production of 619,600 pounds, valued at $118,088, in 1903. It appears that in 1903 and 1904 the production was nearly 300,000 pounds greater than in 1901 and 1902. This large increase in the production of sheet mica during the last two years is due to the very large quantity of the small-sized disks and rectangular sheets of mica that have been prepared for electrical purposes.

The production of scrap mica during 1904 amounted to 1,096 short tons, valued at $10,854, as against 695 short tons, valued at $6,460 in 1903. During 1903, however, there were also reported 964 short tons, valued at $18,580, which were sold in the rough blacks as produced. This probably made at least 800 tons of scrap mica, so that the actual production of scrap mica in 1903 was greater than that in 1904. Of the 1904 production, 610,121 pounds of sheet mica, valued at $100,724, and 200 short tons of scrap mica, valued at $2,000 were produced in North Carolina. This was over nine-tenths of the total production of the United States in 1904.

The imports of mica have, in late years, been several times greater than the home production. This is partly due to the fact that mica from Canada and India, which can be entered at a low valuation, has a tendency to curtail the production of mica in the United States. During 1904, 1,085,343 pounds of unmanufactured mica, valued at $241,051, and 61,986 pounds of cut or trimmed mica, valued at $22,663, were imported into the United States.

Many interesting details concerning the nature, occurrence and uses of mica were given by Doctor Pratt. This report, which is published as an extract from the Survey's forthcoming volume, "The Mineral Resources of the United States, 1904," is available on application to the Director of the United States Geological Survey, Washington, D. C. .

PURIFICATION OF WATER FROM ALGAL CONTAMINATION.

There is not a State in the Union which has not reported difficulty from algal growths in water, and in some communities the odor and taste during certain months of the year have rendered the water absolutely unfit for use. In a few cases the strong odor has even necessitated the giving up of the use of the water for sprinkling the streets and lawns. One water commission in New England considered the trouble due to algæ of so much importance that they were willing to expend about four million dollars

upon devices, and by means certainly effective, in order to try and prevent such difficulties. A city in the far West spent over one million dollars securing new sources of supply so that the algal-polluted reservoirs might be abandoned. In the South we have a case where the algæ led the local authorities to take steps to cause the franchise of the water company to be forfeited, on the ground that they were not furnishing a potable water. The company had spent thousands of dollars in mechanical filters and other devices, without results, and there was no alternative but to install a new supply at a cost of double the one already in use. It is needless to say that a question of so much financial importance has been investigated exhaustively from the so-called practical side, and various recommendations made, all of little or no effect. Finally, the difficulty was relegated to the botanists, who took hold of the problem from the purely scientific standpoint and showed how certain plants were the specific cause of the trouble. It was then a comparatively simple matter, by applying the knowledge gained years ago by Naegeli and others in botanical research, to find a remedy for the difficulty. The only wonder is that it was not thought of before. Within the last six months the method of destroying or preventing the growth of algæ in water supplies, as devised by the Department of Agriculture, has been used with marked success in over fifty water supplies throughout the country, on a scale running into the hundreds of millions of gallons, and causing a saving of money difficult to estimate.—*Scientific American Supplement.*

ACTIVITIES OF THE LAKE SHIPYARDS.

With sixteen vessels under order at Lake shipyards for delivery in 1906 practically all available berths are now taken a year ahead, a condition never existing before. With repairs, the lengthening of vessels and further orders pending for new vessels, full occupation for the lake yards seems now assured for eighteen months. The sixteen vessels, as above, added to those finished, or to be finished, this year, make a total of forty new boats, with a total ore carrying capacity on one trip of 360,500 tons. In a season, estimating twenty trips, they could carry 7,210,000 tons of ore. Such an unprecedented addition to the lake fleet suggests large expectations as to the increase in iron ore shipments in the next few years.—*Iron Age.*

CHINA'S THREATENED BOYCOTT.

The threatened boycott of American goods in China should be very easily remedied if the resolutions of the Shanghai Chamber of Commerce reflect the general Chinese position. It appears that there is no complaint of the exclusion of the Chinese laborer. The resolution of the Chamber of Commerce, addressed to the Board of Foreign Affairs of the Chinese Government, states: "We beg to inform you that the community are discontented with the present situation, and all those connected with this body have decided to cease all traffic in American goods until such time as a satisfactory settlement is arrived at. As this matter concerns all classes

throughout China we sincerely desire that you will instruct our Minister to withhold his signature until the right of entry into America is accorded all traders, students and gentry." If a system could be developed so that the classes named might be given the right of entry without making possible the wholesale migration of Chinese, probably no one would object. America does not wish to see her goods boycotted at a time when the keenest efforts are being made by Europe to get more than its share of the Chinese trade, the tremendous future possibilities of which are being better and better understood.—*Iron Age.*

COAL PRODUCTION.

Reports to the United States Geological Survey for 1904, as collected by Mr. Edward W. Parker, statistician, show that the production of coal last year amounted to 351,196,953 short tons, having a total value at the mines of $445,643,528. Compared with 1903 this shows a falling off of 6,158,463 short tons in quantity, and of $58,080,853 in value. This decrease, although proportionately large in the figures of value, does not indicate any interruption to the generally prosperous conditions which have prevailed during the last eight years. It was simply a natural reaction from the abnormal activity which had been maintained throughout the coal mining regions in 1903, due to the exhaustion of all coal stocks on hand by the memorable strike of 1902. In order to renew the coal stocks and at the same time to provide fuel for immediate use, the coal mines in 1903 were pushed to their utmost capacity, or, one should probably say, to the capacity of the railroads to handle the output. As a result the enormous production of 357,356,416 short tons was recorded. Prices raised high by the famine of 1902 remained high for a large part of the year, and the total value of coal at the mines, before any expense of transportation or selling costs had been added, amounted to $503,724,381, an increase of $136,600,000 over that of 1902. The production in 1904, while less than that of 1903 by 6,159,463 short tons, exhibits a normal increase when compared with the annual production during the ten preceding years. The average price for all coal mined and sold in 1904 was $1.27, as compared with $1.41 in 1903, and $1.22 in 1902. Some day it will be interesting to have brought out the effect of water power development, etc., in reducing coal production.

The Corporation of the Massachusetts Institute of Technology has voted in favor of the proposed alliance with Harvard University. The faculty and alumni of the institute were in a large majority opposed to this union, but the action of the corporation is presumed to be final. The identity of the institute will be retained, and it will have the income of the various funds which now support the Lawrence Scientific School, as well as the income of the large McKay endowment. The alliance as proposed contemplates the erection of a new home for the institute on the Charles River, at a point about opposite Harvard University in Cambridge.

Book Notices.

Traité Theoretique et Pratique d'Electricité. Par H. Pecheux, Professeur de physique et de chimie á l'Ecole Nationale d'Arts et Métiers d'Aix. Avec notes additionneles de J. Blondin et E. Néculcea. Preface de J. Violle, membre de l'Institut. Un volume in 8 de 720 pages, 800 illustrations. (Broché, 17 fr.; relié, 20 fr.) Paris; Librarie Ch. Delagrave, 15 rue Soufflot. 1904.

This work constitutes an exhaustive treatise on theoretical and applied electricity, designed especially for the use of advanced students of the national technical schools of France. It is profusely illustrated, and has apparently been brought well up-to-date. It may be used to advantage as a reference work by all electrical engineers and advanced students of the science. W.

The Urine and the Clinical Chemistry of the Gastric Contents, the Common Poisons and Milk. By J. W. Holland, M.D., Professor of Medical Chemistry and Toxicology in Jefferson Medical College of Philadelphia. Seventh Edition, revised and enlarged, with 71 illustrations. 172 pages Note Book 12 mo. P. Blakiston's Son & Co. $1.00.

This laboratory manual has been so long before the public that, as the numerous editions show, its merits are evident. It is a comprehensive and compact statement of the data in regard to the topics noted in the title, and is printed so as to be available as a notebook. It is liberally illustrated and neatly printed.

The centrifugal process for determining fat, given on pages 169-170 is a slight modification of a well-known process, and it would have been more commendable if Dr. Holland had given credit to the originators of the fundamental process. In most other statements of the book the name of the originator of any process is given and the omission in this case seems strange. H. L.

Reform der Unkostenberechnung in Fabrikbetrieben. Von A. Sperlich. Verlagsbuchhandlung von Gebrueder Jaenecke, Hannover. Preis, Marks 5.

In the above work the primitive methods of accounting formerly used by the masters of small shops, who had only to add their "Master's Pence" to the actual cost of wages and material, in order to arrive at the proper charge for their productions, is compared with the book-keeping and accounting systems now used in large modern manufacturing establishments, where the necessity for expensive machinery, power for driving same, electric light plants, steam heat, railway sidings, Government regulations for sanitation and comfort of workmen, a large staff of managers, book-keepers, clerks, draftsmen, foremen, etc., render the calculations for a proper selling price a complicated and difficult matter, etc., etc.

While under the ancient system an addition of about 10 per cent. to the actual cost of wages and material would be ample to cover general expenses and secure a proper profit, the modern system would require an addition of 100 per cent. to the same basis, depending mainly on the proportion of men and machinery employed.

Three different branches of manufacture have been chosen by the author to illustrate the principles which he wishes to elaborate, the production of the different articles is followed through all its stages, and in each one the proper proportion of expense to cost of labor and material is worked out in detail.

In these days of sharp competition and constant development of new systems, new machinery, etc., it is certainly of the highest importance to the manufacturer to make the most exact calculation of the cost of his productions, to enable him to compete with others, while at the same time securing a legitimate profit, and this work will give him valuable hints in this direction. J. H.

PUBLICATIONS RECEIVED.

Souvenirs Entomologiques. (Etudes sur l'instinct et les mœurs des insectes), par J.-Henri Fabre, correspondent de l'Institut, 9 volumes. Tome IX. — 1 vol. in-8°, avec illustrations, br. 3 fr. 50. From the publisher, Ch. Delagrave, Paris, France.

Jahrbuch für das Eisenhüttenwesen. (Ergänzung zu „Stahl und Eisen".) Ein Bericht über die Fortschritte auf allen Gebieten des Eisenhüttenwesens im Jahre 1902. Im Auftrage des Vereins deutscher Eisenhüttenleute bearbeitet von Otto Vogel. III. Jahrgang. From the publisher, A. Bagel, Daseldorf. 1905. (Price, 10 marks.)

Thermodynamik technischer Gasreaktionen. Sieben Vorlesungen. Von Dr. F. Haber. 8 vo. xvi 296 Seiten. Mit 19 Abbildungen. Muenchen und Berlin. Verlagsbuchhandlurg R. Oldenbourg. (Price, 10 Marks.) From the publisher.

The Pennsylvania State College Catalogue 1904-1905. Fiftieth year. State College, 1905. 324 pages, 12mo.

Annual Report of the City Engineer of the City of Providence for the year 1904. Providence, City Printers, 1905. 81 pages, plates, maps, tables.

Report of the Commissioner of Education for the year 1903, volume 2. Washington, Government printing office, 1905. 1217-2511 pages, 8vo.

Project of Terminal Harbors for the Panama Canal, by Lindon W. Bates, with general plans and sections showing proposed canal terminals, town sites, locks, barrages, outer and inner harbors and naval stations, Panama and Limon bays. New York, author, 1905. 27 pages, plates, maps, Quarto.

Experiments with the Langley Aerodrome, by S. P. Langley. From the Smithsonian Report for 1904, pages 113 to 125 (with one plate.) Washington, Government printing office, 1905.

Fifth Annual Report of the Mining Bureau to the Honorable Secretary of the Interior, by H. D. McCaskey, chief of the mining bureau for the year ending August 31, 1904. Manila, Bureau of public printing, 1905. 44p. illustrations, plates, maps, 8vo.

North Carolina Geological Survey, Bulletin No. 19. The tin deposits of the Carolinas by Joseph Hyde Pratt and Douglass B. Sterrett. Raleigh, Public printers. 1904. 64 pages, illustrations, maps, 8vo.